POWER

Volume 66 New York, August 9, 1927 Number 6

Power per Wage Earner

AS I have several times tried to bring out upon this page, practically everything is reducible to terms of human labor.

When we bought a barrel of flour, as we used to do before the days of bread factories, we paid for the labor of the man who tilled the soil and reaped the grain and carried it to the mill.

We paid for the labor of the man who built and ran the railroad, who invented and designed and built the milling machinery. We paid the wages and the salaries of those who were concerned with the merchandising and distribution of this machinery and its product.

The increased productive power of human labor due to the greater use of power and to the ease with which power has been made universally applicable, by the use of the electric motor and the internal-combustion engine, has made available at reasonable prices many commodities and services that would be unthinkable without such help.

In a statement prepared for the Iowa State Board of Education, Mr. Arthur Huntington says that:

In 1890 one man produced about half a ton of coal; today he produces about four tons and the machinery is developed to increase this to twelve tons.

During the same period the following increase in output per worker has taken place:

From 100 sq.ft. of lumber to 750 sq.ft.

From 500 lb. of iron to 5,000 lb.

From $\frac{1}{4}$ pair of shoes to 10 pairs.

From 20 sq.ft. of paper to 20,000 sq.ft.

From 55 sq.ft. of glass to 3,000 sq.ft.

An expert nailmaker used to make 5 lb. of nails in 12 hours. The output in the nail industry today is 500 lb. per day of 8 hours.

Of course this gain is not all net. Human labor is necessary to make the machines that are used up in the generation, transmission and application of this power.

But it needs no argument to show that power has made and is making the work of the world easier, increasing the purchasing power of a day's work and making possible a lot of comforts, conveniences and advantages that were not imagined by our forbears.

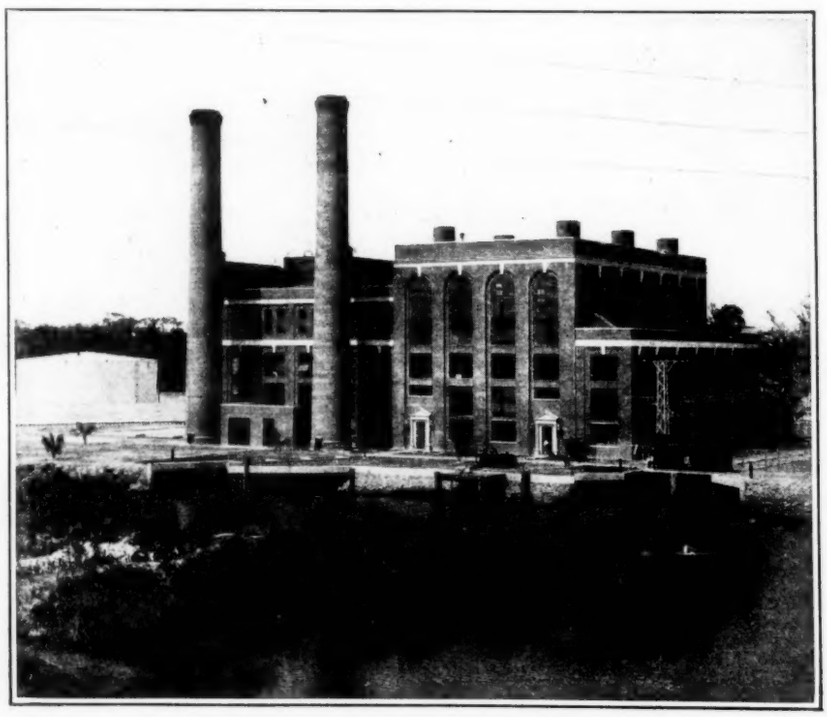
F. R. Low

Inglis Station To Supply West Florida Territory

Oil-Burning Central Station of 25,000 Kw. Present Capacity Built in Wilderness on Exceptional Site

By J. E. SHOUDY

THE 25,000-kw. Inglis steam power station of the Florida Power Corporation is the outcome of the growth of the company and its allies for the last four years. During that time properties have been acquired extending from St. Petersburg, Florida, in the south through the southern section of Georgia. The territory extends some three hundred miles, is about one hundred and fifty miles wide, and has a population of 310,000, with a winter population approximately three times that amount. With the exception of the St. Petersburg plant, which is a modern 18,500-kw. station, the generating plants are of comparatively small capacity and date back a number of years. As the Bayboro Station at St. Petersburg is approximately 125 miles south of the center of the load, the General Engineering & Management Corp., which has the management of the companies, considered it advisable to build the new station somewhere farther north and to make provision for a much larger ultimate capacity.



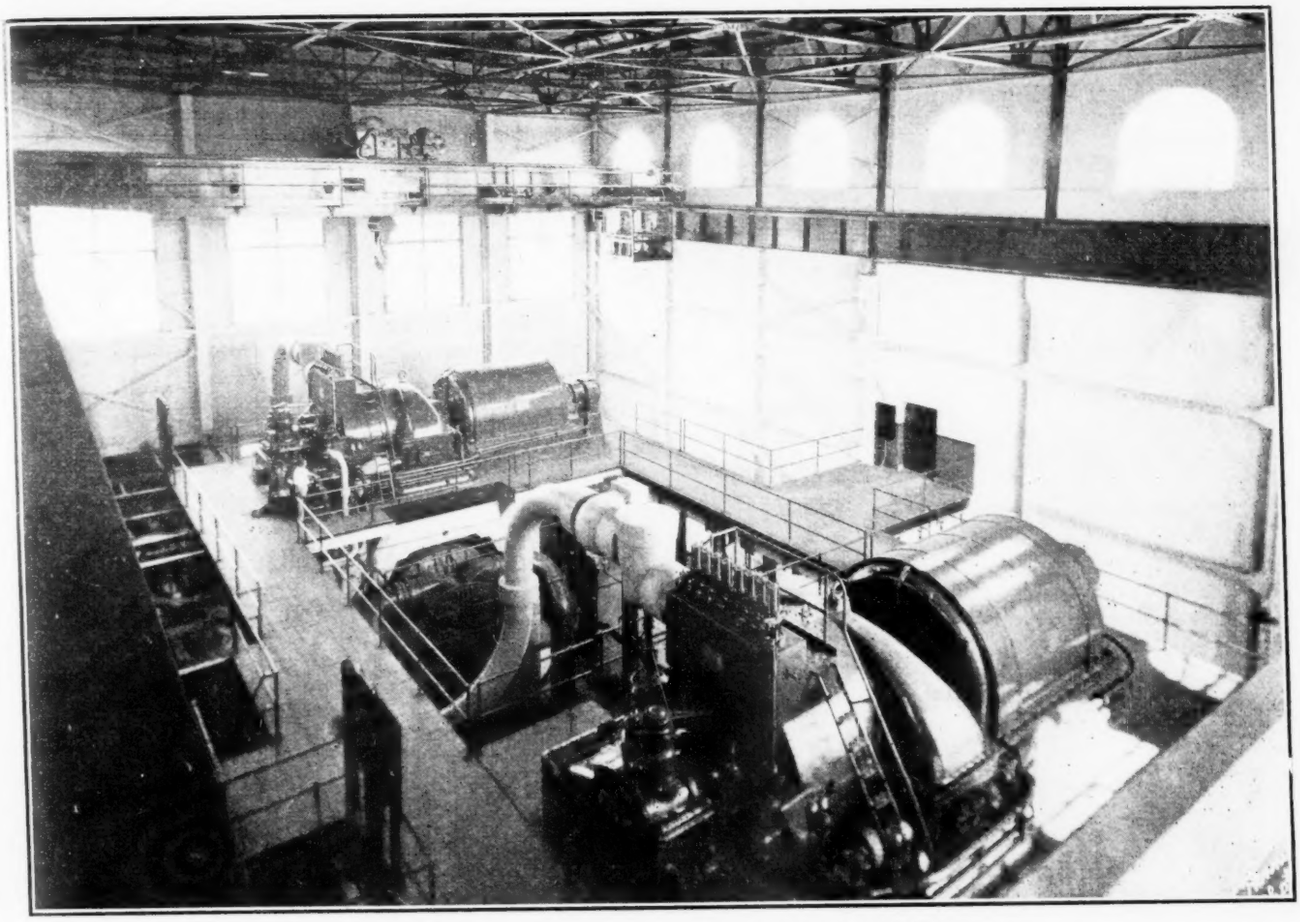
In order to facilitate speed in erection and simplify the boiler room steelwork, detached stacks were employed

A suitable site was finally selected near Inglis on the Withlacoochee River and about 12 miles from its mouth. The river is navigable to this point for vessels of considerable draft, thus affording water transportation for fuel. Moreover, the site is served by the Seaboard Air Line Railway.

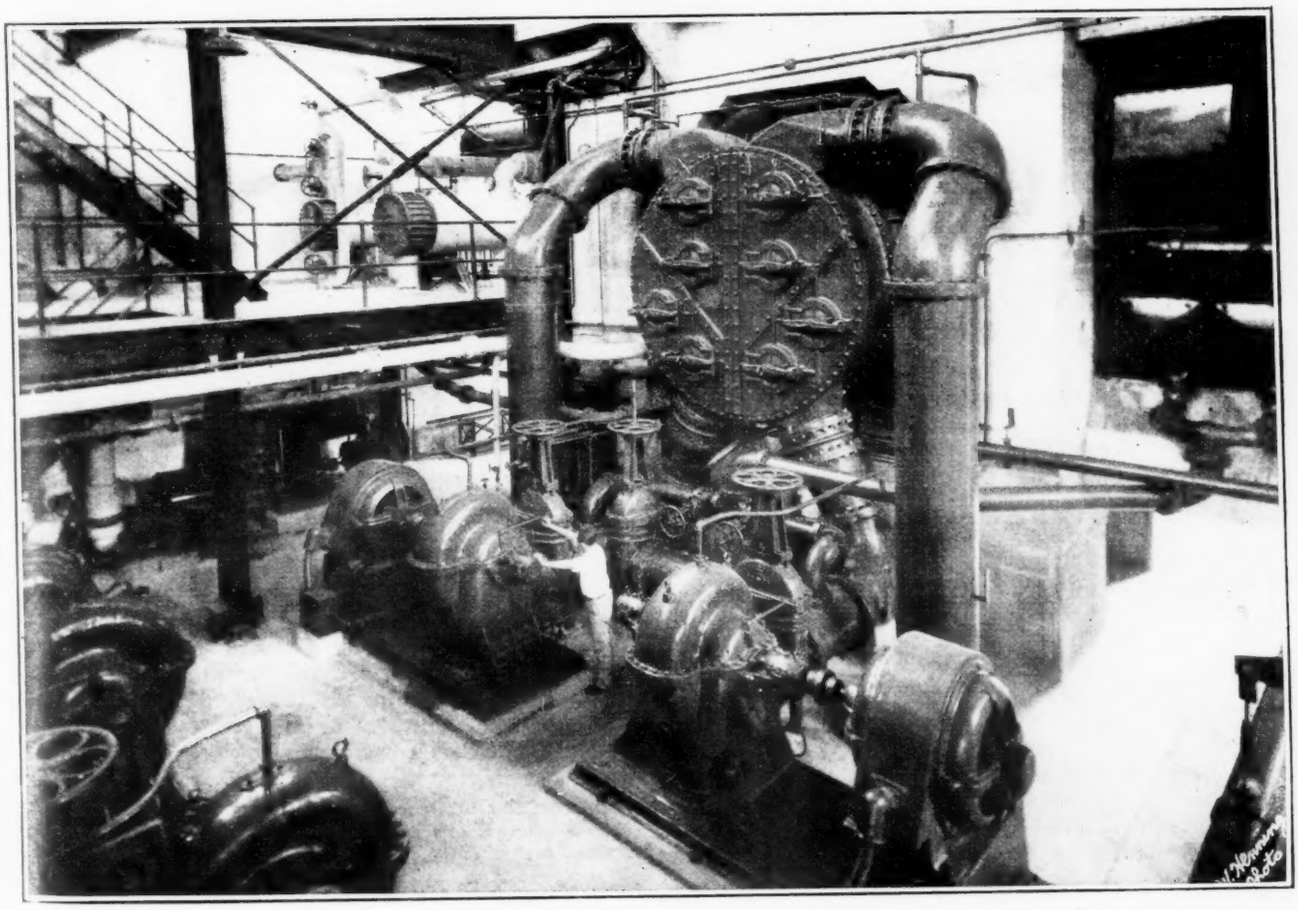
From Inglis transmission lines will connect the entire territory, comprising the west coast of Florida and the southern portion of Georgia, in one transmission system. The major part of this system has already been completed and the rest will be finished some time this year.

The forty acres comprising the site contained an old phosphate plant that had to be completely dismantled. There were no towns of any importance within 10 miles and no labor market within a radius of 150 miles from which to draw the men necessary for the construction. The roads were in poor condition and the railroad tracks to the plant almost unserviceable. On March 15, 1926, the work of dismantling the old phosphate plant and building a camp was begun. Labor was imported from all over the South and housed on the site. The building is of brick and structural steel and embodies a number of interesting features. A monitor has been provided on the boiler roof to allow for possible installation of bunkers and pulverized-coal equipment at a later date. To prevent deterioration from the excessive heat of the boilers, the roof of the boiler room and the monitor is of reinforced concrete covered with Barrett specification roofing. To eliminate trouble from condensation and provide a fireproof roof, the roofs over the turbine room and the electrical bay are gypsum Pyrofil, poured on sheet rock gypsum plaster board to a depth of 4½ in. and covered with Barrett Specification roofing. The windows in the electrical bay along the auxiliary switchboards are stationary, to prevent rain blowing in on the switchboard and other delicate instruments. Elsewhere the inaccessible windows have sash operators.

Radial brick stacks were selected and erected from the ground up in order to simplify the boiler-room steel-



The turbine room is arranged on the island principle



Each condenser is served by two 1,000-g.p.m. circulating pumps

work, and that work on them might proceed without being delayed by the other building construction.

Fuel Supply

Because of the proximity of the plant to the Mexican oil fields, with consequent low freight rates and the ease of transportation and storage, oil was selected as the fuel. This is brought from Tampa to Inglis in the company's own barges, or it may be brought by tank cars. In either event it is pumped into one of two 20,000-bbl. fuel-oil storage tanks.

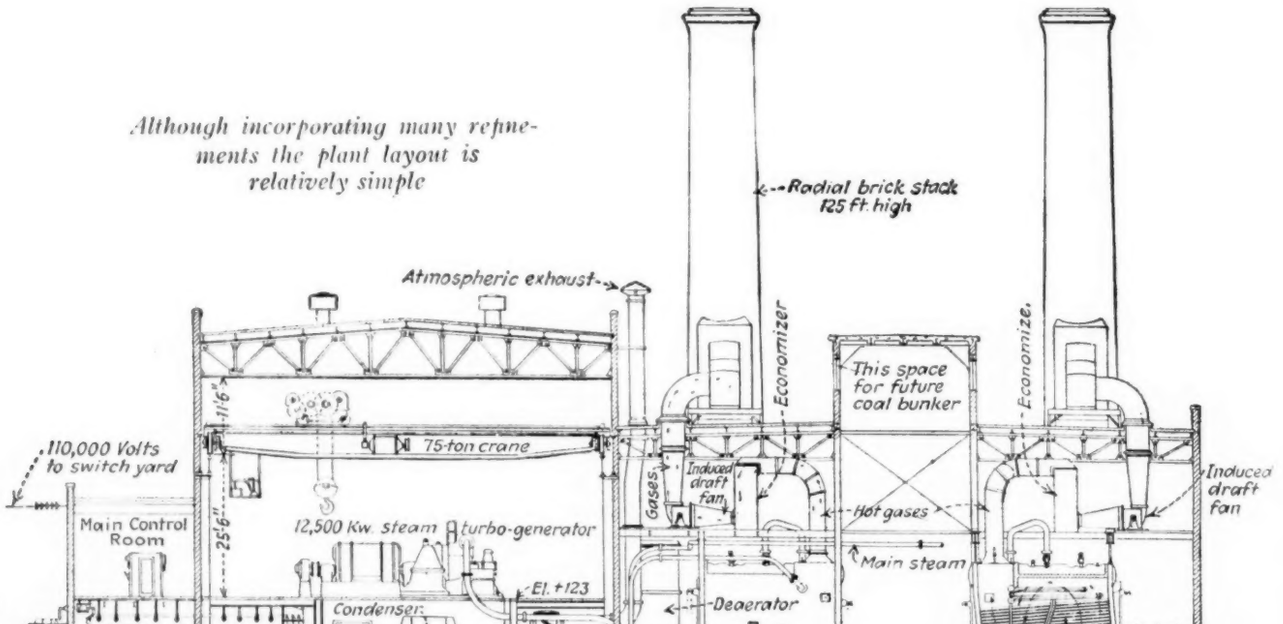
A mechanical fuel-oil burning system is provided in which the oil not used in the burner is recirculated back to the main tanks. A viscosity meter has been installed in the steam line to the oil heaters, in order to maintain a constant viscosity of the oil to the burners by varying the temperature of the oil leaving the heaters proportionate to the increase or decrease in the supply of steam to the heaters.

The six 9,360-sq.ft. boilers are set in two rows of three with a common firing aisle between. They are designed for 350 lb. working pressure, but are operated at 325 lb. and 200 deg. superheat. Four forced-draft fans are provided, each with a capacity of 50,000 cu.ft. a minute against a static pressure of 6 in. when handling air at a temperature of 120 deg. F. They are direct connected to constant-speed motors. Two of these fans are placed on each side of the house and discharge into interconnected ducts under the floor. Induced-draft fans of a capacity of 45,000 cu.ft. a minute against a static pressure of 4 in. when handling gases at 400 deg. F. are provided and driven by variable-speed motors. Each boiler is equipped with an industrial economizer.

Each boiler has five burners and the settings are arranged so that air is sucked through them to a common duct, connecting with the suction side of the forced-draft fans. This arrangement provides for positive circulation of air through the settings, keeping them cool and adding to the life of the brickwork, and also provides for some preheated air to the burners. The air-cooled settings extend to the bottom row of tubes, and from this point on to the top of the boilers a standard firebrick wall is used.

The turbine room is arranged on the island principle with the first installation of the two 12,500-kw. turbine-

Although incorporating many refinements the plant layout is relatively simple



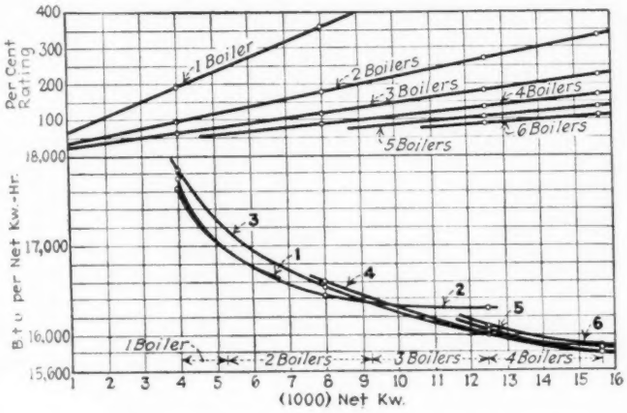
generators on platform foundations extending well above the main floor so as to provide ventilation and light on the condenser floor as well as accessibility of the main auxiliaries to the overhead crane. The two main turbines are 17-stage, single-cylinder type, designed for two-point bleeding. The water rates on the turbines at 28½-in. vacuum are included in the accompanying table of equipment. The main generators are provided with a water fire quenching system and a closed-type generator air cooler, using a siphonic water system with individual seals on the air cooler discharges and raw water from the circulating pumps. Each generator drives directly its exciter. A spare motor-driven exciter set, available for either unit, has been provided.

The condensers are set along the axis of the turbine room and the circulating water pumps, two for each unit, are arranged in the center of the condenser room floor. These condensers are of the two-pass radial-flow type. The water boxes are divided vertically so that half of the

condenser may be cleaned while the unit is in service. Both ends of the tubes are packed with metallic packing. There are two motor-driven circulating water pumps per unit, each having a capacity of 10,000 g.p.m.

Heat Balance

The essentials of the heat-balance arrangement provide for bleeding steam at two points in the main units to two low-pressure heaters. The gland steam is condensed in an independent gland seal condenser for each unit. The oil cooler and radojets are both cooled by condensate



Operating characteristics with one to six boilers in service

from the main condensers with a special arrangement which has worked out satisfactorily at the Bayboro plant at St. Petersburg. A recirculating connection taken off the condensate line after the radojet, permits the condensate not required in the system for any given load, to pass back to the hotwell of the main condenser, the float control valve on this line, actuated by the level of the water in the hotwell under all load conditions. The condensate pumps are arranged for constant-speed drive.

One of the advantages of this system is that it prevents cavitation in the hotwell pumps at light loads. It also provides for the absorption of the heat reclaimable in both the oil cooler and radojet by the condensate which is passing into the system. The additional condensate loses its heat on its return to the condenser, and both the oil cooler and radojet are given the advantage of a constant quantity of clean water at all loads. After passing through the intermediate pressure heater, the condensate enters the surge tank, into which all high-pressure drips and drains from the oil heaters, together with the distilled makeup water from the evaporator, are discharged.

The boiler-feed pumps, two motor-driven and one steam-driven, are supplied from the surge tank, and then the feed water is pumped through a high-pressure evaporator-condenser to the economizers and thence to the boilers.

The possibility of brackish water in the Withlacoochee River was such as to justify the installation of an evaporator to insure a constant supply of pure water to the boilers at all times. High-pressure steam at 300 lb. is used in the coils of the evaporator, which is of the double-effect type and arranged so that either effect can be run independently of the other. An open heater is provided for heating the water before it enters the evaporator. The surge tank previously mentioned is provided with a deaërating attachment for decreasing the oxygen content of the feed water before it enters the boilers, to avoid difficulties with corrosion.

All auxiliaries, with the exception of two steam-driven condensate pumps and one steam-driven boiler feed pump, are arranged for motor drive with remote control. Induced-draft fans and boiler feed pumps are provided with slip-ring motors and variable-speed controls.

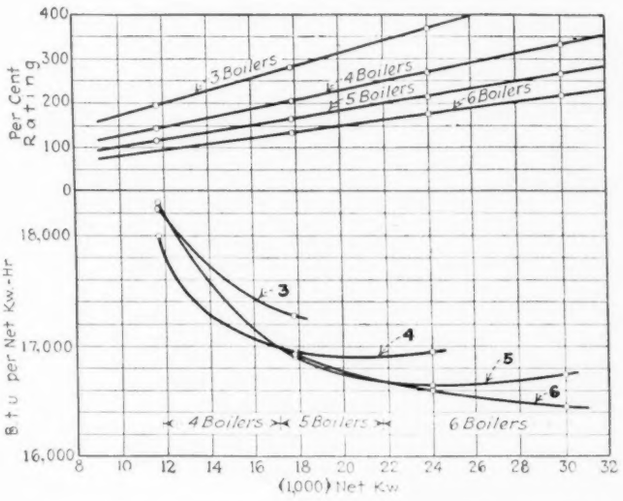
The auxiliaries are so arranged that either main generator can be operated independently of the other unit. A 200-kw. house turbine-generator is installed for starting purposes. An air compressor and boiler wash pump are both installed, either of which system can be used for turbining the tubes when necessary.

All high-pressure steam piping conforms to the 400-lb. standard. Sargol joints are used on all these lines down to 4 in., below which square Van Stone flanges are used. Boiler-feed piping is made up of square Van Stone flanges, wrought-iron boiler-feed piping having been used throughout.

The insulation on the high-pressure steam piping is guaranteed for 700 deg. F. and is applied in two layers, the one next to the piping being a special heat-resisting type and the outer cover being 85 per cent magnesia. All air ducts and other flat surfaces are covered with 85 per cent magnesia in block form securely fastened and wired in place.

The main switching equipment is in an out-door substation with outdoor step-up transformers tied directly into the main generator units.

Active construction work was begun April 6, 1926, and



Operating characteristics with three to six boilers in service

on Dec. 16, 1926, exactly 8⅓ months later, the first unit was put into commercial operation. On Jan. 13, 1927, the second unit was placed in service, and the final work, such as heat insulation, painting and lighting, was completed March 19, 1927, when the plant was turned over to the operating force after a total construction period of approximately sixty weeks.

The plant, which was constructed under the supervision of John Coilins, Jr., and Harry J. Bauer, engineers, and W. A. Shoudy, advisory engineer, is designed for an ultimate capacity of 100,000 kw. It is built with one end inclosed by a temporary siding of protected metal to be removed when an addition is made; and arrangements have been provided for easy connection of the new units.

PRINCIPAL MECHANICAL EQUIPMENT OF INGLIS STEAM STATION

GENERAL

Capacity installed (1926), kw.	25,000
Capacity ultimate, kw.	200,000
Designers and constructors	General Eng. & Mangt. Corp.
Built for	Fitkin Utilities
Operated by	Florida Power Corporation

IMPORTANT RATIOS

Boiler heating sur. to installed kw.,	2.25 sq.ft.
Furnace volume to installed kw.,	1.18 cu ft
Furnace volume to boiler surface,	0.525 cu.ft.
Vol. of boiler room per installed kw.,	25 cu.ft.
Volume of turbine room per installed kw.,	21.7 cu.ft.
Area of boiler room per inst'ld kw.,	0.43 sq.ft.
Area of turbine room per inst'ld kw.,	0.60 sq.ft.
Condensing sur. to installed kw.,	1.52 sq.ft.
Circulating water to installed kw.,	1.60 g.p.m.

FUEL-OIL EQUIPMENT

Two oil sotrage tanks, 20,000-bbl. each	Chattanooga Boiler & Tank Co.
Two 56-g.p.m. rotary plunger motor-driven booster pumps	Kinney Mfg. Co.
Three 26-g.p.m. motor-driven screw pressure pumps	Wm. E. Quimby, Inc.
Six double furnace fronts (one per boiler)	Edge Moor Iron Co.
Two 5-pass. fuel-oil heaters	Griscom-Russell
36 burners, air registers, etc. (6 per boiler)	Peabody Engrg. Corp.
Viscosity regulator	Peabody Engrg. Corp.
Two twin strainers	Elliott Co.

BOILERS

Manufacturer	Edge Moor Iron Co.
Type	Three-pass, 4-drum, horizontal
Number installed	Six
Heating surface, sq.ft.	9,361
Furnace volume, cu.ft.	4,915
Heating surface per cu.ft. of furnace volume, sq.ft.	1.9
Boiler pressure, gage, lb. maximum	350
Furnace air-cooled walls	M. H. Detrick Co.
Area in sidewalls each boiler,	592 sq.ft.
Area in end walls each boiler,	432 sq.ft.

SUPERHEATERS

Manufacturer	Power Specialty Co.
Ratio superheater surface to boiler tube heating surface	0.114
Superheat	200 deg. F. at 275 per cent rating

ECONOMIZERS

Manufacturer	Power Specialty Co.
Ratio economizer surface to boiler surface	0.467
Increase of feed water temperature	97 deg. F. at 300 per cent rating

DRAFT EQUIPMENT

Fan manufacturer	B. F. Sturtevant
Number per boiler; forced draft	2 for 3 boilers
Induced draft	1 per boiler
Capacity per minute; forced draft	50,000 cu.ft.
Induced	45,000 cu.ft.
Max. steam pressure, lb. abs.	7.5
Pressure, inches of water; forced draft, in.	6
Induced draft, in.	4
Drive; forced draft, 75 hp., 440-v. three-phase, squirrel-cage motor	Allis-Chalmers
Drive; induced draft, 75 hp., 440-v. three-phase slip ring motor	Allis-Chalmers
Air ducts	Littleford

STACKS

Vendor and erector	Alphons Custodis
Number and type, Radial brick	1 per 3 boilers
Diameter inside; at bottom	11 ft. 0 in.
At top	8 ft. 6 in.
Height above foundation, ft.	125
Breaching and flues	Littleford Bros.

PRIME MOVERS

Manufacturer	General Electric Co.
Number installed	Two 12,500-kw.
Number of stages	Nine
Bleeder Points	6th stage 7.5 lb. abs.; 4th stage 23.2 lb. abs.
Steam pressure at throttle, lb.	300
Steam temperature, deg. F.	635
Water rate at 9,375 kw.; 29 in. vacuum; 0.8 P.F.-10.4 lb. (without bleeding)	
Generator	Three-phase, 60 cycle, 6,600 volt
Exciter	Direct connected 85 kw. 250 volt
Generator air coolers; 2 per unit.	About 650 sq.ft.
Ventilating air	35,000 c.f.m.
Cooling water required	About 300 g.p.m. each
Air filters, two	Reed Air Filter Co

MAIN UNIT AUXILIARIES

Condensers (two)	C. H. Wheeler Mfg. Co.
Steam capacity, lb. per hr.	135,000
Surface, sq.ft.	19,000
Ratio condenser surface to kw.	1.52
Circulating Pumps (one)	C. H. Wheeler Mfg. Co.
Number	Two per condenser
Capacity each, g.p.m.	10,000
Head, ft.	20
Drive—75 hp., induction motor	General Electric Co.
Condensate Pumps	C. H. Wheeler Mfg. Co.
Number	One turbine and one motor driven per condenser
Capacity, g.p.m.	400
Air Pumps	C. H. Wheeler Mfg. Co.
Number and type	One Radojet per condenser
Capacity each free air, c.f.m.	27.8

HEAT TRANSFER EQUIPMENT

Low-Pressure Heaters	Two—Griscom-Russell Co.
Capacity each with friction loss of 10 ft., lb. per hr.	121,900
Max. steam pressure, lb. abs.	7.5
Intermediate Pressure Heaters	Two—Griscom-Russell Co.
Capacity each with friction loss of 9 ft., lb. per hr.	121,900
Max. steam pressure, lb. abs.	23.2
Gland Seal Condenser	Two—Griscom-Russell Co.
Capacity each with friction loss of 5 ft., lb. per hr. of gland steam	1,750
Surge Tank Heater & Vent Condenser	Cochrane Corp
Capcity, gal.	5,000

EVAPORATOR EQUIPMENT

Type	Two-effect high heat level
Evaporators	Two Griscom-Russell
Feed Water Heater	One open type, Griscom-Russell
High-Heat-Level Condenser	One Griscom-Russell

PUMPS

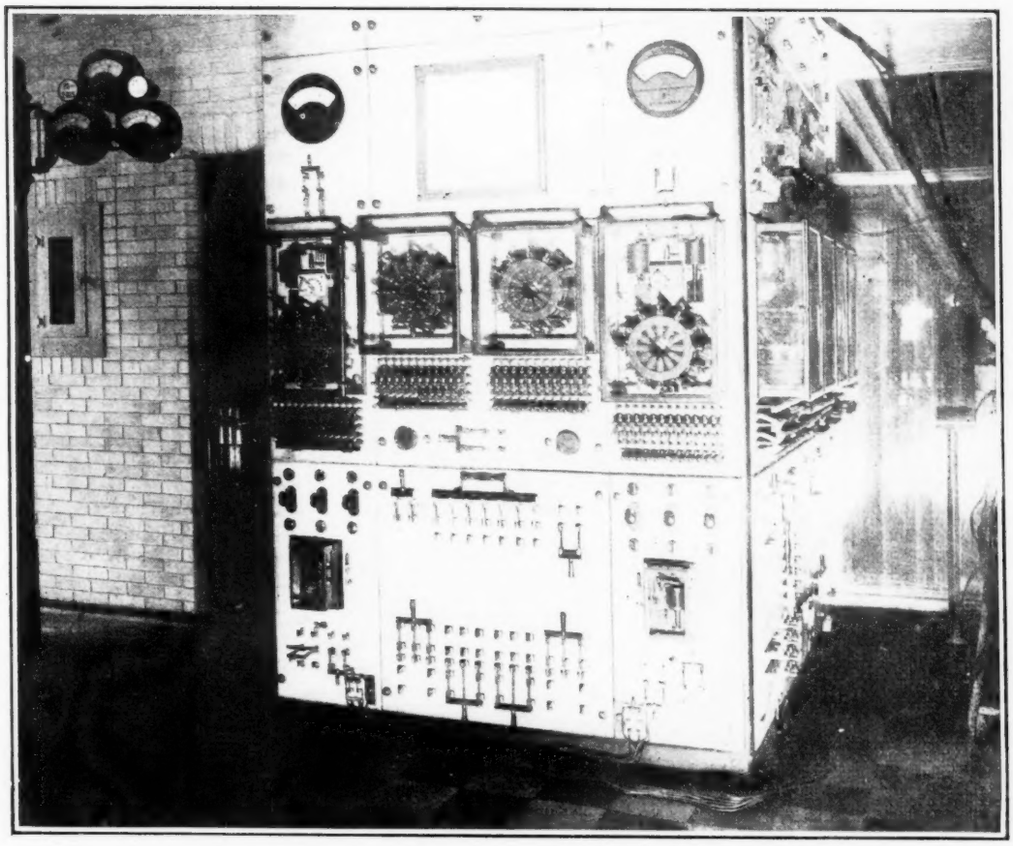
Boiler Feed—4 in., 5-stage, 440 lb., turbine type	Worthington Pump & Machy Co.
Two 350 g.p.m. driven by 150-hp., three-phase, slip-ring	Allis-Chalmers motors
One 350 g.p.m. driven by 150-hp.	General Electric Curtis turbine
Fire & Boiler Wash—3 in. 2-stage 200 g.p.m., volute	Worthington Pump & Machy. Co.
Driven by 40 hp.	Allis-Chalmers motor
Service Water—Two, 350-g.p.m., 202 ft. head, centrifugal pumps driven by 25-hp., motors	Allis-Chalmers
Heater Drip—Warren single-stage, double-suction, 40 g.p.m.	Vincent Gilson
Low Level Storage Tank—Open-type, single-stage, vertical cent.	American Well Wks.
Gland Seal Water—Warren single-stage, double-suction, 50 g.p.m., 85 ft. head	Vincent Gilson
Turbine Oil Purifying System—Weinman single-stage, side suction centrifugal, 10 g.p.m., 35 ft. head	Peerless Engr. Co.
Fuel Oil Unloading—Horizontal double duplex piston, double reduction power pump, 240 g.p.m., 70 ft. head	Worthington Pump & Machy Corp.
Fuel-Oil Unloading—Horizontal double-duplex steam-driven piston pump	Knowles
Evaporator Feed—Two Warren 4-stage, opposed impeller, split case, centrifugal, 347ft.head.	Vincent Gilson
Driven by 20 hp.	All s-Chalmers

VALVES, PIPING AND INSULATION

Motor-operated valves	Chapman: W. J. Neville
High-pressure valves	Chapman: Crane / Walworth, W. J. Neville / Lunkenheimer
Atmospheric relief valves	C. H. Wheeler Mfg. Co. / Atwood & Morrill Co.
Boiler safety valves	Consolidated Safety Valve Co.
Economizer safety valves	Consolidated Safety Valve Co.
Superheater safety valves	Consolidated Safety Valve Co.
Non-return valves	Edward Valve Mfg. Co.
Relief valves	Ashton Valve Co.
Emergency trip throttle valve	Schutte & Koerting
Float control valves	Foster Engineering Co.
Circulating water valves	Chapman: W. J. Neville
Evaporator feed-water heater—Temperature Controller	Kieley & Mueller
Blow-off valves: Yarway Tandem	Yarnell-Waring Co.
Small Forged Steel Globe Valves.	Edward Valve Mfg. Co. / Lunkenheimer
Fabricated piping	Pittsburgh Piping & Equip. Co.
Standard piping	Pittsburgh Piping & Equip. Co. / Crane Co.
85 per cent magnesia insulation	Eherts Magnesia Co.
High-temperature insulation	Armstrong Cork Co.
Sheet mineral wool insulation.	Banner Rock Products Co.
Standard valves	Reading: S. H. Knoff Co / Crane Co. / Chapman: W. J. Neville / Lunkenheimer: W. J. Neville

MISCELLANEOUS MECHANICAL EQUIPMENT

DeLavel Oil Purifying Equipment	Turbine Equipment Co.
Turbine oil coolers	Andle Engrg. Co.
Soot blowers	Diamond Power Specialty Co. (Vincent Gilson)
Feed-water regulators	Copes: Northern Equipment Co.
High-pressure drainers	Copes: Kissick-Fenno
Heat-balance equipment drainers.	Griscom-Russell Co.
Steam traps	Sweet & Doyle Mfg. Co. / Strong, Carlisle & Hammond
Steam air ejectors	Schutte & Koerting



Large automatic generator voltage regulator installation

Care and Adjustment of Voltage Regulators

By WILLIAM H. TURNER

Voltage Regulator Engineering Department, General Electric Company

GENERATOR voltage regulators in the past were considered rather complicated, but this impression has been gradually changed by the experience gained by many with the large number that are in service. Any regulator can be better understood by considering the function of various elements separately. Failure to understand this piece of apparatus leads some to criticize it, although the real trouble may be in the method of operating, in the exciter or in the exciter field rheostat. The suggestions given in this article should be helpful to the operator for securing a maximum of service from the regulator.

With a vibrating-type regulator controlling one alternating-current generator and one exciter, the generator's main field rheostat should be left in the all-out position. If a part of the main field rheostat is cut in, the regulator should keep the alternating-current voltage unchanged but, to do so, must raise the exciter voltage, which imposes a higher duty upon the relay contacts than necessary, and there will be unnecessary heating losses in the generator's field rheostat.

When one regulator controls two or more generators in parallel and the characteristics of the generators are different, it is necessary to cut resistance in the main field rheostat of the generator which tends to take the wattless current, so as to improve its power factor. The generators tending to operate at the better power factor should have their rheostats all out. In other words, the main field rheostats can be used to equalize the power factor of the generators. But the rheostat, in one or more of the generators' field circuits, should be all out and care should be taken not to turn in more resistance than necessary on the others.

Response of the regulator depends upon how quickly the exciter under control responds, and to a large extent upon the amount of exciter field rheostat in circuit. Small exciters are usually faster to respond to a regulator than large ones because of a lower inductance in the field circuit. In special cases where an extremely quick response is desired, the field coils of the exciter are paralleled, or the field coils are excited from a separate source.

On 125-volt shunt-wound exciters it is generally satisfactory to have in circuit a sufficient amount of external field resistance to reduce the exciter voltage from 125 to 25 in from 6 to 8 seconds. When 250-volt shunt-wound exciters are under regulator control, they should have sufficient resistance in the exciter field rheostat to reduce their voltage from 250 to 50 in from 6 to 8 seconds. The point on the exciter rheostat thus determined is called the operating point, and the rheostat contact arm should be on this point when the exciter is under regulator control.

The operating point of a compound-wound exciter is obtained in the same manner, except that the exciter should have one-half to three-quarters load on it when the test is made.

After the operating point of the exciter field rheostat has been determined, the rheostat should be divided into the recommended number of parts with the aid of a low-reading, direct-current voltmeter. To divide or tap an exciter field rheostat, its arm should be on the operating point and the cutout switches at the bottom of the regulator should be open. With the exciter running at normal speed, assuming the voltage across the rheostat is found to be 15 volts and that three sets of relay contacts are required for control, the portion of rheostat in circuit should be divided into three parts so that the voltage across each part equals 5 volts, Fig. 1. The resistance sections in field rheostats vary or, as it is called, taper, therefore the division should not be made by guess or mechanical measurement.

In order to obtain stable parallel operation of two or more exciters that are under the control of one regulator, it is important that all exciters be undercompounded. Shunt-wound exciters have a natural

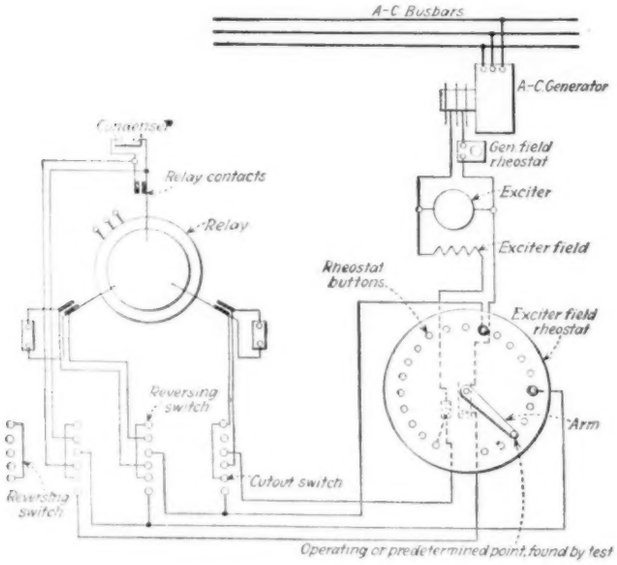


Fig. 1—Diagram of field rheostat divisions and connections to regulator

drooping-voltage characteristic, and trouble is seldom experienced in paralleling these exciters. If one of the exciters tends to take more than its share of the load, this can easily be remedied by turning in a portion of the equalizer rheostat of this exciter. The equalizer rheostat is connected in the exciter-field circuit, but is not shunted by the regulator relay contacts.

Compound-wound exciters are often found flat compounded and sometimes overcompounded. Such exciters will not operate well in parallel unless the compounding is changed. Many compound exciters have german-silver shunts connected across the series field-winding

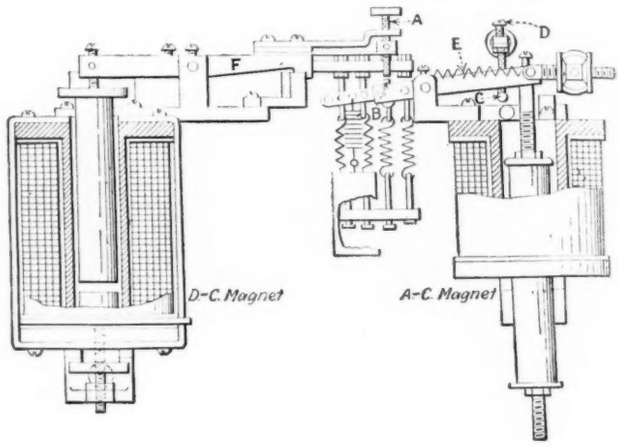


Fig. 2—Main contacts and magnets

terminals and can be undercompounded by decreasing the resistance of the shunt. This method, if carried too far, results in slowing up the response of the exciter. An easy way to undercompound an exciter is to move the brushes slightly forward in the direction of rotation. They should not, however, be moved to such an extent as to cause sparking. This method of undercompounding does not slow up the response of the exciter.

Care of Relay Contacts

The relay contacts of a voltage regulator operate directly across the exciter field rheostat and, from the operator's or maintainer's viewpoint, deserve the most attention. These contacts should be inspected once a week or once a month, depending on the severity of service. The surfaces of the contacts can be kept in good condition by passing a magneto file between them after the regulator is cut out of service. A magneto file has a double cutting edge, measures approximately $\frac{1}{32}$ in. thick and can be purchased in almost any hardware store. After filing, the gap between the relay contacts should be adjusted so that it is $\frac{1}{32}$ in. between open contacts. The life of the contacts is also increased by reversing their polarity by means of the reversing switches at the bottom of the regulator. The switches should be reversed at least once every 24 hours. This can easily be done without taking the regulator out of service.

The most universally satisfactory relay contacts have tips composed of chemically pure silver. Silver has low resistance and makes positive contact. Silver oxide is a white powder which falls off without affecting the operation of the regulator. Silver relay contacts work well on light or heavy field currents, provided the correct value of condenser or capacitor is used. Each set of relay contacts has a condenser in parallel to decrease the arcing. When the relay contacts open, the condensers are charged, and when the contacts close, they discharge through the contacts. With silver contacts too much condenser effect causes them to stick or weld together.

On exciters having heavy field current at rated load and voltage, say 10 to 18 amperes, it is sometimes better to use two condensers in parallel across each set of contacts, thus increasing the condenser effect. The condenser effect can be reduced by connecting two in series

across each set of contactors or by connecting a resistance in series with one condenser. In some installations good results are obtained without condensers. Another way is to connect condensers across the field of the exciter. The standard condenser for use on vibrating regulators has one micro-farad capacity.

Some operators prefer to use tungsten relay contacts because, where they do not give trouble, they have long life and require little maintenance. Tungsten contact tips are very hard and were the old standard contact material. Tungsten was discarded as standard because its oxide has a high resistance and does not fall off easily. The most applicable places for tungsten is on light field current up to approximately 6 amperes. In some cases tungsten relay contacts are used and so connected that two or three sets of relay contacts are in parallel across the same section of exciter field rheostat. Thus, if one set of contacts fails to make, the duty is shifted to the other set or sets and the faulty set clears itself by vibrating action.

Care of Main Contacts

The main contacts *A* and *B* in Fig. 2 are composed of a special metal which is extremely hard and cannot be filed. About semi-annually the surface should be cleaned by rubbing the tips by hand upon a fine carborundum stone. They should not be ground on a revolving stone, as the metal is expensive. After the contacts have been cleaned, they should be set in the regulator, using the gage blocks. The gage blocks should be so set that the levers rest upon them, and the upper main contact should be adjusted until it just touches the lower contact.

When the regulator is holding constant alternating-current voltage, the alternating-current lever *E* should be in a floating position; that is, the alternating-current

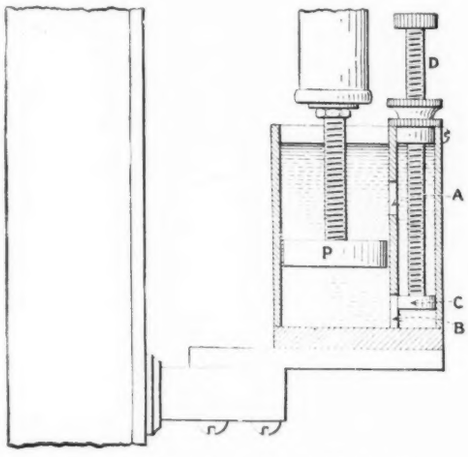


Fig. 3—Section through dashpot

lever should not be touching the limit pins *C* or *D*, but should be in some position between these pins. Under any normal condition of load the alternating-current lever should not touch the limit pins. These limit pins are for the purpose of adjusting the minimum regulated exciter voltage and the maximum regulated exciter voltage. Care should be taken to see that the limit pins are not touching the lever under any normal operating condition. The regulator should hold constant alternating voltage upon the generator from no load to full load.

The minimum regulated exciter voltage is determined by the position of limit pin *D*. The maximum exciter voltage that the regulator can call for is determined by the adjustment of limit pin *C*. By the proper setting of this limit pin the regulator is effectively prevented from seriously overloading the generator in emergencies.

With low alternating-current voltage impressed upon the alternating-current coil of the regulator, the lever will be resting upon the lower limit stop *C* and will cause the main contacts to close. The closing of these contacts causes the exciter voltage to increase and the main contacts to open because of the increased pull on the direct-current magnet. The exciter usually responds quickly to the action of the regulator contacts, therefore the main contacts will vibrate although the alternating-current lever may rest against the stop. The position of the alternating-current lever governs the value of exciter voltage. With no load upon the generator the alternating-current lever is in the highest position, which calls for a low exciter voltage. With full load upon the generator, the alternating-current lever drops near the lowest position, demanding a higher exciter voltage. With constant load and power factor upon the generator, the alternating-current lever remains definitely fixed in position, and the vibration is caused by the direct-current side of the regulator.

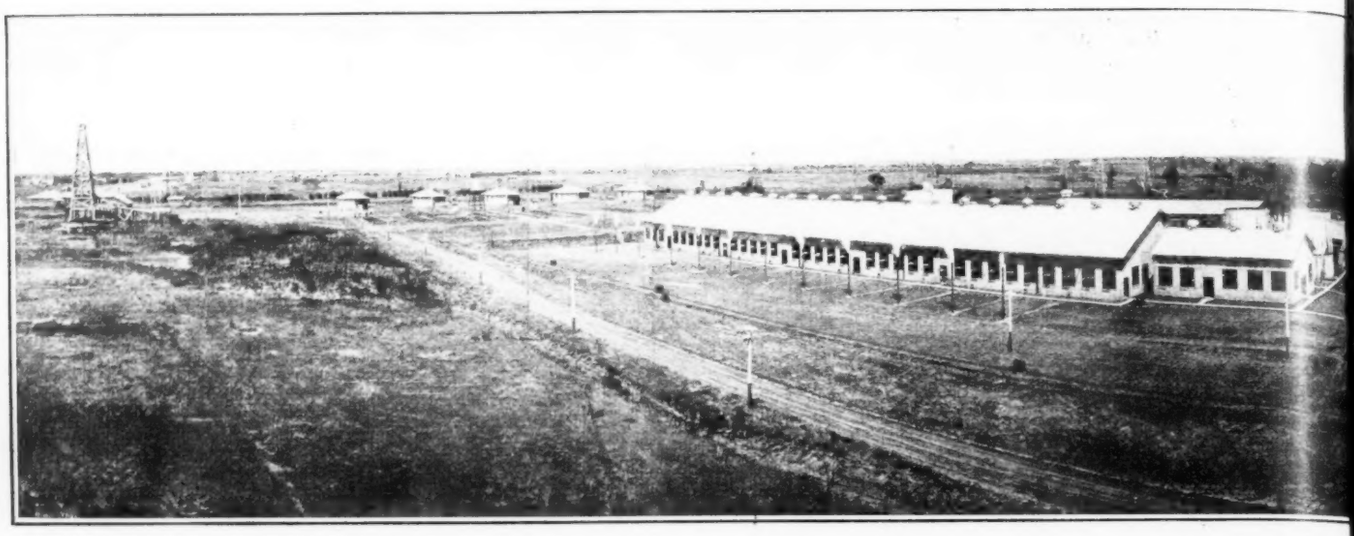
Dashpot Construction

The dashpot construction is shown in Fig. 4. The dashpot should be so adjusted that the plunger moves quite freely, but not so freely as to cause a hunting or pumping action. When the dashpot is properly adjusted, the regulator will quickly correct the voltage after a load change. If the dashpot has too much retarding effect, the regulator would correct the voltage resulting from a large load change too slowly.

The normal position of the piston *P* is about midway between portholes *A* and *B*. Piston *C* can be raised or lowered by turning thumbscrew *D*. The position of piston *C* determines the amount of dampening, since it can cut off all circulation of oil through the bypass or allow free circulation by being below the top edge of porthole *B*.

The dashpot should be filled with a good grade of light engine or lubricating oil to above ⅛ in. from the top. So-called dashpot oil should not be used as it becomes sticky or gummy when exposed to air.

The Actual Vertical Lift measured from the standing level of the suction water to the useful standing level to which the water is raised, generally is known as the static head against which a pump works and is found by measurement of the difference of the elevations, or by determination of the difference shown by pressure gages when the water is at rest. The dynamic head is the total head against which the pump works and consists of the static head plus all losses of head except those within the pump itself. Hence the dynamic head, or head actually delivered by the pump, is equal to the difference between the head with which the water enters and that with which it leaves the pump. This head can be measured when the pump is running by taking the difference in readings of absolute pressures indicated by pressure gages placed at the same level in the suction and discharge lines close to the pump; or where the pressure gage on the suction side must be at a lower level than the one on the discharge side, the head represented by this difference of gage levels must be added to the difference of head interpreted from the gage readings.



Turning Gas into Peppy Gasoline

A GOODLY proportion of the gasoline consumed is obtained from a source unheard of a few years ago. In former days the gas from wells was either wasted or pumped through pipe lines for domestic or industrial gas burning. Someone discovered that a part of this gas could be condensed into a high-test high-priced gasoline, which, when mixed with a petroleum product of low gravity, would make a suitable gasoline for automotive use.

All gases can be liquefied by sufficient cooling, but only a small percentage can be utilized within existing pressure and temperature ranges, and it is the recovery of this portion that has created the vast casing-head gasoline industry.

Methods of such gasoline recovery vary somewhat, but the diagram in Fig. 1 illustrates one system. Gas comes in from the gas field under 5-lb. gage pressure and is compressed in the low-pressure cylinder of a double-acting compound compressor belt-driven from a natural-gas engine. The gas at 50-lb. pressure is passed through a shell-and-tube condenser, where it is cooled to about atmospheric pressure before flowing to the high-pressure cylinder of the compressor. The gas leaves this cylinder at 250 lb. gage and first flows through a single-pipe cooler, where any gasoline that will condense at the existing pressure and temperature is drained off. The gas then passes through the inner pipe of a double-pipe cooler on its way to the "expansion" cylinders. These cylinders are essentially the steam end of a compound-steam duplex air compressor such as is shown in Fig. 3. The gas in expanding in these cylinders performs work and loses enough of its internal energy to drop very low in temperature. The exhaust flows to the double-pipe condenser where, in passing between the inner and outer pipe, it gives up all the condensed gasoline, which is trapped as shown in Fig. 1. The gas, which is at 0-gage pressure, then flows into the compression cylinders of the "expanding" machine and its pressure is raised to about 25-lb. gage, to force it back into the gas field line.

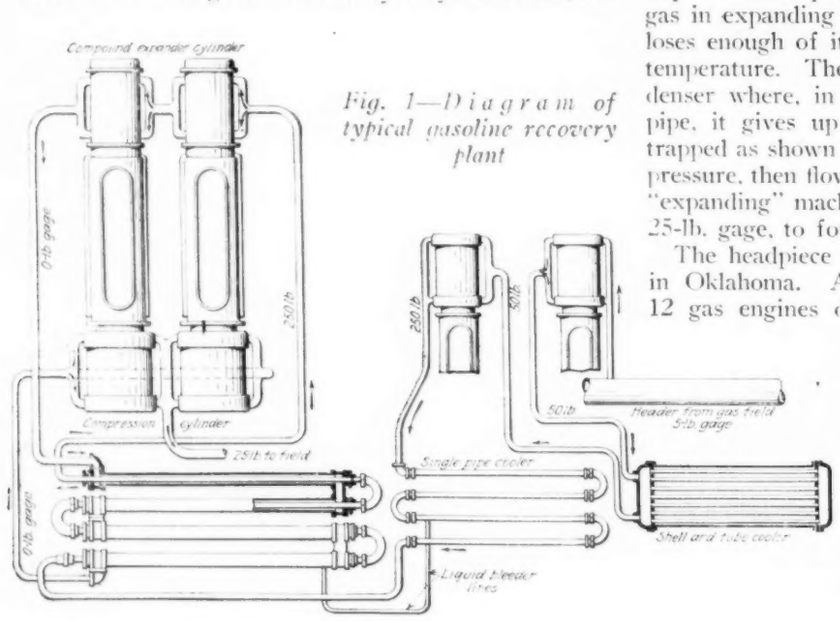
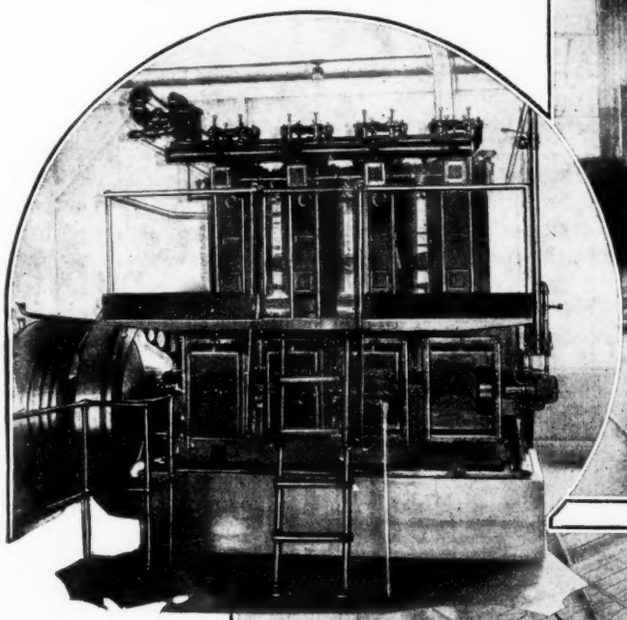


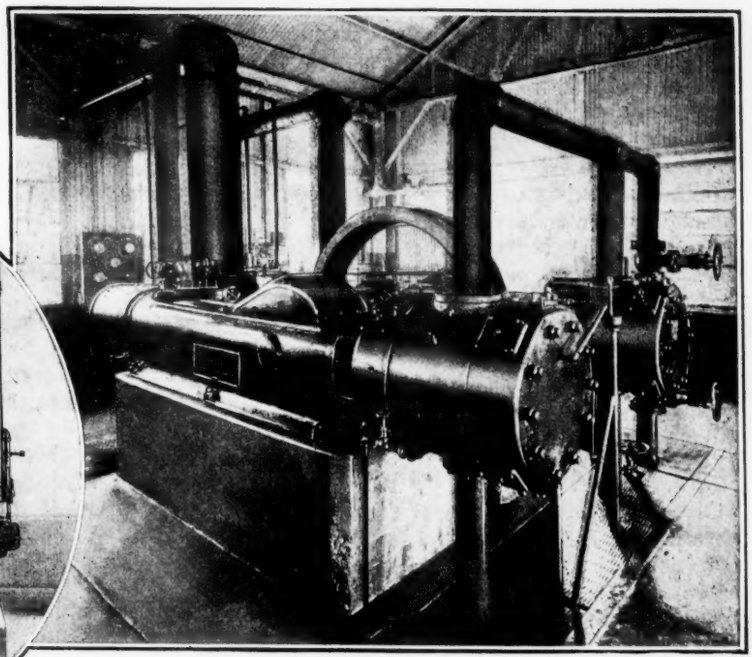
Fig. 1—Diagram of typical gasoline recovery plant

The headpiece shows a large gasoline recovery plant in Oklahoma. As the exhaust pipes show, there are 12 gas engines driving compressors in this particular plant. The vertical multiple-cylinder gas engine is largely used, that shown in Fig. 2 being a 250-hp. Foos unit operating at 165 r.p.m. Such engines are belted to the compressors, Fig. 4 illustrating a common arrangement, showing the interior of the plant seen in the headpiece. The photographs were obtained through the courtesy of the Ingersoll-Rand Co., builders of the compressors.

Fig. 2 (below)—Vertical gas engine used to drive compressor

Fig. 3 (right)—Expander compressor lowers gas temperature





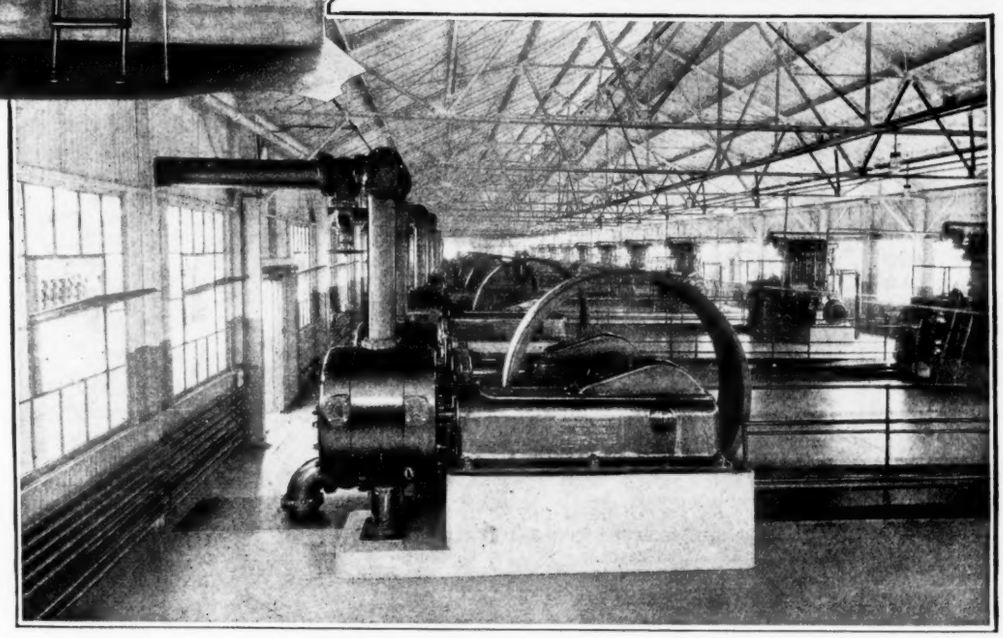


Fig. 4 (right)—Layout of compressors and engines in one plant

The Heat Pump

By A. G. Christie

EUROPEAN engineers were much interested a few years ago in the subject of the "heat pump." This is a device in which it is proposed to compress steam from a low pressure to a higher pressure by means of mechancial energy or by high-velocity steam jets. One's first reaction to such an idea is that there is nothing to the suggestion from a power point of view, for any compression process is less than 100 per cent efficient, and therefore more energy is spent in compressing the steam than can be recovered in its later expansion. This impression is correct, and the heat pump as a power proposition can be regarded as impracticable.

There are many cases in industry, however, where, instead of the potential energy to develop power, one wishes to utilize the heat content of the steam at a certain temperature.[1] These temperatures may be higher than that of the available steam supply. It may frequently be the case that the higher-temperature steam may be secured more cheaply by the compression of low-pressure steam than by the employment of a high-pressure steam generator. DeBaufre developed a process in this country a few years ago where he compressed a portion of the low-pressure steam leaving an evaporator by means of a jet of high-pressure steam. The steam, after compression, together with that used in the jet, was delivered to the evaporating coils of the evaporator. It will thus be apparent that the large latent heat of the steam was used over and over again in the evaporator. About as high efficiency as with a triple-effect evaporator using high-pressure steam was obtained. The introduction of the low-pressure multiple-effect film evaporator had a retarding effect on the development of the DeBaufre process.

Where the Heat Pump Could Be Used to Advantage

Certain large central stations are being built to employ reheating cycles where the reheating of the working steam is to be done by high-pressure steam taken from the turbine throttle. If 600-lb. steam pressure is used at the throttle, it will be apparent that the amount of reheating will be limited as the low-pressure steam can be reheated only to the saturation temperature of the high-pressure steam. This is where a heat pump could be used to advantage. The low-pressure steam would first pass over heating coils containing steam at throttle pressure and temperature and would be heated to as high a temperature as at present proposed. Additional high-pressure steam from this primary reheater, now in a saturated condition, could be passed through a heat pump and raised to pressures ranging from 1,500 to 2,000 lb. per sq.in. This steam could be delivered to a second set of heating coils in the reheater, so that the temperature of the reheated steam could be materially raised over present practice, to the saturation pressure of 1,500- or 2,000-lb. steam.

On account of the small volumes of steam at these pressures, the heat pump would not be large. As centrifugal compressors would be used, the efficiency would be low, but could be improved by further development of such compressors. Furthermore, compression losses appear as added heat in the high-pressure steam, and may be usefully employed for reheating. Even if low efficiencies are assumed for the heat pump, this cycle may show an improvement in efficiency over reheating with high-pressure steam alone. The heat pump warrants further study and development in this connection.

[1] A heat pump has been in successful operation for some time compressing steam for use in ovens at the plant of the National Cash Register Co., Dayton, Ohio. This was described by Guy B. Randall in *Power*, March 9, 1926.—Editor.

What Do You Know?

The answers are on page 213

AN ENGINEER has stated that it's easier to answer than to ask questions. Is this true? The ten questions below were framed in 30 minutes. Can you answer in less time, that is, correctly? Time yourself and then check the editor's answers.

Ques. 1—Does it require more work to compress a given weight of gas from a pressure P to a pressure P_2 when the compression is isothermal than it does when it is adiabatic?

Ques. 2—Is there a thermal gain in feeding water into the cylinder of a kerosene or semi-Diesel engine?

Ques. 3—Why does cylinder oil prove unsatisfactory with superheated steam, although quite satisfactory as a lubricant as long as saturated steam is used?

Ques. 4—What is the number of expansions occurring in an engine having a 6 per cent clearance, if the apparent cut-off is three-eighths stroke?

Ques. 5—What is meant by the critical point of steam?

Ques. 6—What is the Ogee joint on a Manning vertical boiler?

Ques. 7—What is the diversity factor of a power system?

Fig. 8—What is the usual installed horsepower per ton of refrigerating capacity of an oil-engine-driven ice plant?

Ques. 9—Is the force acting along the connecting rod of an engine ever greater than the total force or pressure developed in the cylinder?

Ques. 10—Who was John E. Sweet?

A Few Thoughts on the Meaning of Heat

By Thomas M. Gunn

THERE are many facts and figures with which engineers deal every day that have a depth of meaning beyond the complete comprehension of man. It is truly fortunate that it does not require a full understanding as to what electricity is to enable us to generate it and use it. The force of gravitation is, perhaps, even less understood as to its real nature than is electric energy, though we are subject to its laws and are able to utilize them in the generation of hydraulic power.

Similarly, we understand the general laws governing the generation and utilization of heat, but there are limits beyond which we are unable to delve, in determining just what heat is. In fact this not an engineering problem, but rather one of pure science. This may not, however, be always true, because the scientific revelations of one day become the tools of engineers on the next day. Because of this fact the two, engineering and science, are constantly drawing closer and closer together and overlapping in many ways, with increasing mutual interest.

It is generally accepted that heat is a form of energy which depends upon the movements of the molecules of matter. This conception is worthy of thought and leads us into some interesting conjectures.

Heat Does Not Decrease with Time

First, we know that if a body could be completely isolated from other bodies—a condition approached in a thermos bottle—it would remain at a constant temperature. In other words, heat does not decrease with time. So there is a difference between molecular motions which constitute heat, and mass motions such as the vibrations of a tuning fork, since these mass motions gradually die out and are lost in friction, while heat does not die out. It may pass from a warmer body to a colder body, or it may be converted into another form of energy, as in the steam engine or internal-combustion engine, and it may become involved in the chemical changes of matter, but this does not indicate its disappearance. The vibrations of the molecules do not die out as do those of the tuning fork. Hence, we understand molecules to be perfectly elastic.

Secondly, we commonly deal with matter in three forms—solid, liquid and gaseous. In the first there is a bond of some sort holding the molecules in a certain relation to one another, resisting any distortion; while in the second the molecules move past one another with relative freedom, but are still so close together as to resist compressive forces. In the gaseous condition there is not only an almost perfect freedom of flow, but there is a tremendous increase in volume beyond that of the liquid and a new characteristic of compressibility that follows quite a definite law relating it to pressure and temperature. Hence, there must be a great difference between the molecular motions which constitute heat in a solid, in a liquid or in a gas. In the first we may conceive an interlocking of the molecules, preventing them from passing one another, but vibrating with an amplitude so that their relative positions remain practically constant. Increasing temperature widens the amplitude [1] of vibrations, expanding the solid until the interlocking ceases and the molecules can now pass one another. The substance then becomes a liquid. Further rise of temperature increases the volume of the liquid until the molecular motions become so violent as to cause molecules to fly off into space. There they meet other molecules, with which there is set up a chaotic condition of motion in every direction, with innumerable impacts and rebounds. The substance has then become gaseous.

Without going into the theoretical analysis of these molecular motions, we can apply a bit of engineering sense to the question, How fast do these molecules move? We will not arrive at an exact figure perhaps, but the result is not so far from that given by chemists and physicists as to give a false impression. Take, for example, atmospheric air at a temperature of 60 deg. F. What can we learn of the velocity of the average molecule in a pound of this air?

The Velocity of Molecules

If heat is, as defined, the energy of molecular motion, it is kinetic energy, which may be calculated by multiplying the mass by half the square of the velocity. We may not be able to learn what the mass of one molecule is, but we know that all the molecular masses in a pound of air will total to the mass of one pound. So we may write, as the total kinetic energy of one pound of air-molecules E in foot-pounds,

$$E = \frac{v^2}{2g}$$

where v is the average molecular velocity, feet per second, and g is the acceleration of gravity, 32.2 ft. per second per second. To find velocity, this equation may be rearranged in the form,

$$v = \sqrt{2gE}$$

We must make some reasonable assumption as to the total amount of heat energy E in a pound of air at 60 deg. F. Air becomes liquid under atmospheric pressure at about 314 deg. below zero F., so 60 deg. F. is about 374 deg. above the liquid temperature. Multiply this by 0.169, the specific heat of air at constant volume, and the result is 63.2 B.t.u. of heat energy, which has gone into molecular kinetic energy above that existing at the low temperature of liquid air. Let us be satisfied with this figure as representing the total, although we know it must be somewhat greater. Each B.t.u. of heat energy

[1] Provided the substance is free to expand.—Editor.

is equivalent to 778 ft.-lb. of mechanical energy, so

$$E = 778 \times 63.2 = 49{,}200$$

and the average molecular velocity in the air is

$$v = \sqrt{2 \times 32.2 \times 49{,}200} = 1780 \text{ ft. per sec.}^2$$

Now, here is a calculation from our own engineering data, on a conservative basis, that tells us that at normal room temperature we are being bombarded on all sides by molecules of air traveling with the speed of a bullet. We have not, however, calculated the velocity with which our own bodily molecules are bombarding the air. As we give off heat, we may say that our bodily molecules have such high velocities as to disturb those of the air around us more than the air molecules disturb our own.

Latent Heat

In any substance there are forces tending to draw molecules together. We know the law of gravitation as acting between masses. The gravitational attraction of the earth mass for any mass that we may lift is its weight. If we hold two masses side by side, there is a mutual attraction between them, though it is so small as to be detected only in careful laboratory tests. But between the molecules of substances the forces of attraction are often intense.

Now, when a solid is heated, the more intense motion of the molecules causes an increase in the average space between them, evidenced by expansion. When melting occurs, there is a complete rearrangement of the molecules, and in most substances there is an increase in volume. The change from solid to liquid also requires the disengagement of the molecules from one another, so that they can move freely, or flow. These changes require the addition of energy, which is supplied in the form of heat, "the latent heat of fusion." While this change is taking place the temperature remains constant.

The tensile strength of a solid is evidence of strong mutual attraction of the molecules. In a liquid molecular attraction becomes less conspicuous, but can be observed as surface tension, which holds drops together and causes bubbles to take a nearly spherical form. In the gaseous condition, however, the mutual attraction of molecules is quite completely overcome by their velocity. Like centrifugal force that holds the earth in its orbit against the gravitational attraction of the sun, the velocity of the molecules of a gas is so intense that they fly in all directions, perhaps in orbits, or rebounding from one another or from the walls of the vessel. It is the impact of these molecules against the confining walls that produces what we know as the pressure of the gas. It is also this molecular velocity that causes one gas to diffuse into another and prevents them from separating, even though one gas may be much heavier than another. We might say that in the gaseous condition the molecules are moving with such violence that the forces of mutual attraction can no longer be detected.

Latent heat of vaporization may be interpreted, then, as the heat or molecular kinetic energy necessary to separate the molecules against their mutual attractions and to push away any exterior resistance to expansion, such as atmospheric pressure or that of a piston.

This is a spectacular process, vaporization. Imagine the molecules of water, like a quivering mass of rubber balls. Now strike these a rapid succession of blows with a bat, and we may crudely visualize these balls flying in all directions. If they are in a box, they will rebound from the walls and again strike their fellows, in utter chaos of rapid motion. If the cover is removed from the box, the balls will fly out in all directions.

To set the balls into such chaotic motion requires much energy on the part of the wielder of the bat. So, vaporization requires much energy. We are familiar with the figure, 970 B.t.u., which is the latent heat of steam at atmospheric pressure. Compare this with the weight of water vaporized. Each B.t.u. is the heat equivalent of 778 ft.-lb.

$$970 \times 778 = 754{,}660 \text{ ft.-lb.}$$

If, instead of heating the water, this energy were expended in lifting it, it would be sufficient to lift it to a height of over 140 miles.

Begging permission for only one more flight of the imagination, take one pound of fuel oil, which can generate about 18,000 B.t.u. of heat through combustion.

$$18{,}000 \times 778 = 14{,}004{,}000 \text{ ft.-lb.}$$

This energy, obtained from one pound of fuel, if all convertible to mechanical work, would suffice to raise a pound weight to an altitude of 2,650 miles. This may also be compared to the work that a powerful human being might do in ten days of hard labor.

All this takes us nowhere in particular at the present moment, unless it be to give us a feeling of added respect for heat, this marvelous agency that we utilize in generating mechanical and electric power. There can surely be no higher profession or calling than that of utilizing, with intelligence and understanding, these laws of nature, controlled for the purposes of economy and conversation, and applied to the comfort and welfare of mankind.

[2]The kinetec theory gives the velocity of air molecules as 1,630 ft. per sec.

Pumping Boiler Feed Water*

THE desirability of supplying feed water to boilers at temperatures as near as possible to those of the steam is generally recognized. Not only is the operation of the boilers improved, but the bad effects of cold feed on the plates are avoided.

One of the reasons injectors were so largely used for feeding boilers in the past was the fact that they supplied hot feed water. With the introduction of feed-water heaters and economizers injectors have generally been replaced by feed pumps, the injectors, when used, being held in most cases for emergency purposes.

Reciprocating pumps are not entirely suitable for pumping feed water into boilers, owing to the alternate acceleration and retardation of the water. With centrifugal pumps, however, the water is pumped with less shock, the action being more like the steady flow of water in a pipe. In addition there is always more or less trouble when hot water is being pumped with reciprocating pumps, probably because of the expansion of the metal comprising the pump and the production of steam as the water is drawn in on the suction.

Centrifugal pumps, when designed for pumping hot water, are quite satisfactory for feeding boilers. When used for this purpose, however, the intake pipe must be about three times as large as it would ordinarily be for cold water. Sharp turns and constricted passages, both in the pump itself and in the connecting pipework, must be avoided in order to prevent the release of steam at the constricted points. This trouble generally occurs when there is a sudden demand for water. In addition the efficiency of the pump is lowered and difficulty is also encountered in maintaining the supply of water.

*Abstract of article by W. E. Warner in the July, 1927, issue of *Cheap Steam*.

Condenser Experience in a Large Central Station

CONDENSERS, like every other piece of power-house apparatus, require constant attention to assure efficient operation and continuity of service. Where the tubes are of an inferior grade or the packing is improperly applied, failures are bound to occur, resulting in a large destruction of tubes, leaks, and a heavy maintenance expense.

In the plant being described, there is one single-compartment surface condenser installed for each main generating unit. These condensers are entirely independent and each one is provided with an atmospheric relief valve to take care of the exhaust of the turbine in case of a vacuum failure.

The tubes in these condensers were originally of the cast core billet type, but owing to excessive failures they were replaced by B.w.g. No. 18 cup process Admiralty metal. All new tubes are tested with 80-lb. air pressure before installation to guard against service failures. Long ferrules and wearing tips are applied at the inlet ends of the tubes to protect the tubes against excessive wear due to the erosive action of the circulating water. It has been found that they protect the ends of the tubes very effectively and that they last about five years. Corset-lacing packing for the tube-end joints has been adopted as standard, because it was determined that when it is carefully and properly installed little or no trouble is experienced. Extensive experiments were carried on with metallic packing, but it proved unsatisfactory because it dried out, making it difficult to check the resulting leaks.

After experimentation with different systems of tube cleaning, it was decided that the most effective method was that of blowing rubber plugs through the tubes with compressed air and using a hand lance when necessary. Two men can clean the larger condensers in about eight hours when this method is used. The cleanliness of the condensers is determined by observing the vacuum, the temperature of the circulating water, and the load on the turbine, and they are cleaned at intervals varying with the season. Throughout the summer months the cleaning period is often less than seven days, whereas during the winter months it averages about every 30 days. Marine growth and deposits which are found on the tube sheets often are removed with a stiff wire brush. Owing to the infrequent use of the smaller main generating condensers, the cleaning process is often performed about every three months.

The temperature of the condensate averages from 60 deg. F. to 95 deg. F. However, it has been noted as low as 50 deg. F. in the winter and as high as 115 deg. F. in the summer. The circulating water at the inlet varies from 27 deg. F. to 76 deg. F., and the rise in temperature in passing through the condenser varies from 5 deg. F. to 15 deg. F., depending upon the load on the turbine and the quantity of circulating water being used. The speed of the circulating-water pumps is varied according to the operating conditions, which results in variations of 60 to 120 lb. of circulating water per pound of steam condensed, and velocities in the tubes of about 4 to 8 ft. per sec. Approximately 6½ lb. of steam per square foot of condenser surface is condensed at full load.

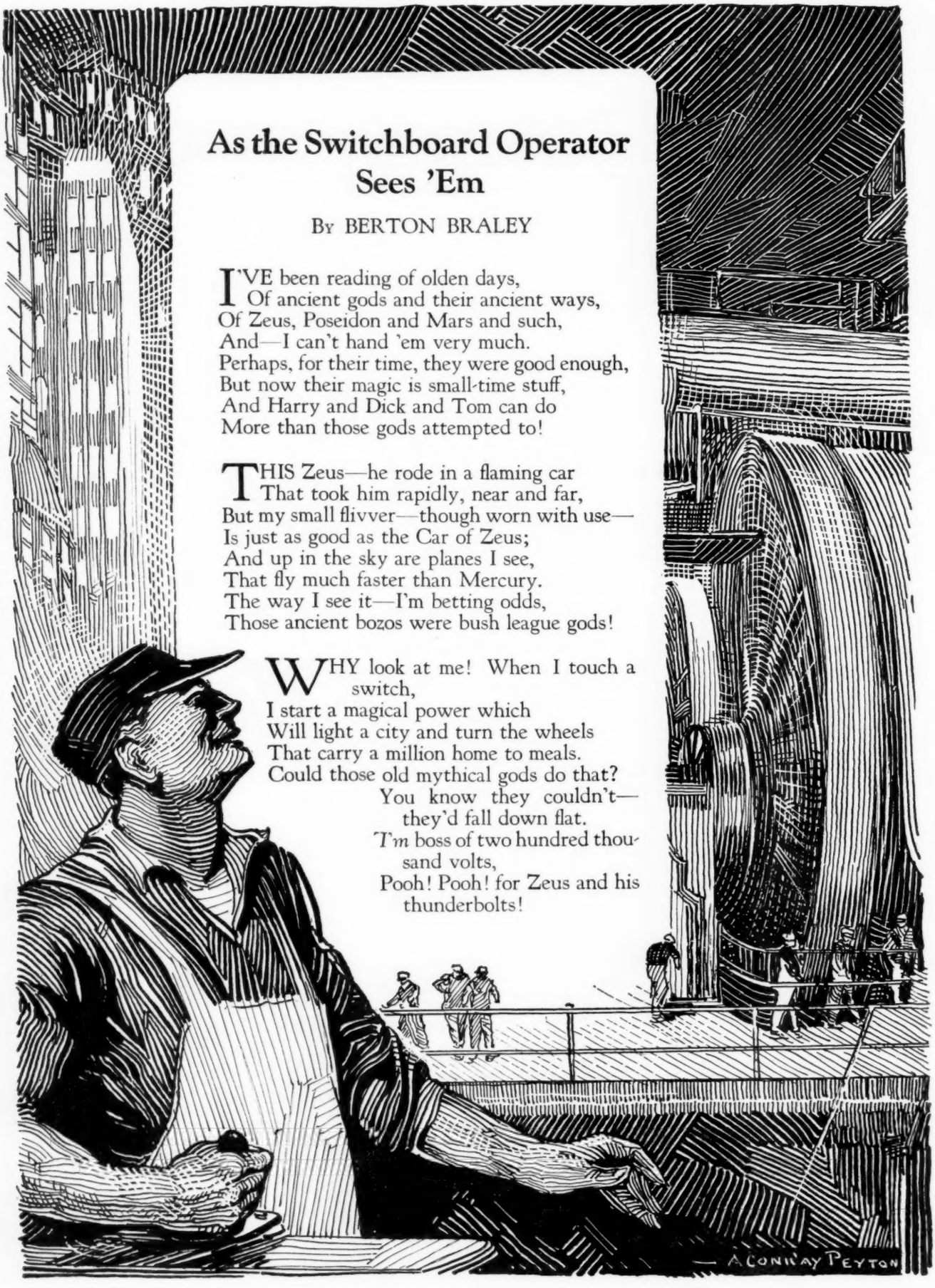
The newer condensers are provided with special cooling tubes close to the suction of the dry air pump, for the purpose of increasing the density of the vapors going to the air pump, and as a result increase the pump capacity. They are equipped with a high-and-low-water alarm, and it has been found desirable to provide a connection between the steam and water sides for priming purposes.

Unfortunately, the system of keeping costs in this station is such as will not permit the segregation of condenser maintenance costs. However, a table is given showing the capacity, number of tubes, etc., of each condenser, together with the hours of service and the tube replacements, which no doubt will prove interesting.

DATA ON CONDENSERS UP TO JANUARY 1, 1927

Condenser number	1	2	3	4	5	6	7	8	9	10	11
Square feet of surface	18,650	19,000	19,000	16,000	19,000	22,300	30,042	27,800	50,000	50,000	50,000
Number of tubes	4,802	4,811	4,496	3,895	5,423	5,350	9,000	8,330	9,550	9,550	9,550
Length of tubes	16′ 3½″	16′ 3½″	16′ 3½″	16′ 3½″	16′ 3½″	17′ 3″	17′ 3″	17′ 3″	20′ 2¼″	20′ 2¼″	20′ 2¼″
Size of tubes O. D.	1″	1″	1″	1″	¾″	1″	¾″	¾″	1″	1″	1″
Tube ends January 1, 1927	1″ ferrule	3″ ferrule	1″ ferrule	1″ ferrule	1½″ W. Tip	1″ ferrule	1″ ferrule	1″ ferrule	5″ W. Tip	5″ W. Tip	3″ ferrule
Commercial Starting Dates											
Starting dates (S. D)	10/17/04	10/21/04	11/28/06	12/1/07	9/22/08	9/26/11	9/14/11	10/20/14	2/26/19	4/4/20	12/18/22
Total hours from S. D. to F. R. or P. D.	33,192	36,768	49,728	17,448	48,384	100,512	125,304	41,856	64,200	59,112	35,376
Turbine hours from S. D. to F. R. or P. D.	18,775	18,917	19,543	10,579	24,665	47,791	42,530	33,265	45,275	40,012	28,086
Tube losses from S. D. to F. R. or P. D.	66	48	3	120	117	256	197	580	132	58	71
First Retubing Dates											
First retubing (F. R.)	8/1/08	12/31/08	7/31/12	11/27/09	3/31/14	3/15/23		Lower Half 7/30/19			
Total hours from R. F. to S. R. or P. D.	131,736	128,904	125,928	149,856	91,776	34,600		65,088			
Turbine hours from F. R. to S. R. or P. D.	61,682	60,007	21,698	23,909	15,333	14,514		26,841			
Tube losses from F. R. to S. R. or P. D.	69	534	25	2	10	57		91 *244			
Second Retubing Dates											
Second retubing date (S. R.)	8/12/23	9/15/23			9/18/24						
Total hours from S. R. to P. D.	29,688	28,896			20,016						
Turbine from S. R. to P. D.	13,873	10,929			1,921						
Tube losses from S. R. to P. D.	38	33			7						

P. D.—Present date—January 1, 1927. * Damaged by turbine wheel.



As the Switchboard Operator Sees 'Em

By BERTON BRALEY

I'VE been reading of olden days,
Of ancient gods and their ancient ways,
Of Zeus, Poseidon and Mars and such,
And—I can't hand 'em very much.
Perhaps, for their time, they were good enough,
But now their magic is small-time stuff,
And Harry and Dick and Tom can do
More than those gods attempted to!

THIS Zeus—he rode in a flaming car
That took him rapidly, near and far,
But my small flivver—though worn with use—
Is just as good as the Car of Zeus;
And up in the sky are planes I see,
That fly much faster than Mercury.
The way I see it—I'm betting odds,
Those ancient bozos were bush league gods!

WHY look at me! When I touch a switch,
I start a magical power which
Will light a city and turn the wheels
That carry a million home to meals.
Could those old mythical gods do that?
You know they couldn't—they'd fall down flat.
I'm boss of two hundred thousand volts,
Pooh! Pooh! for Zeus and his thunderbolts!

Troubles in Refrigerating Plants Due to Compressor Design

By Roland L. Tullis

THE operating engineer is frequently censured for shutdown and troubles that are due, in fact, to the poor design of the compressors

SOME great improvements have been made in the design and manufacture of refrigeration machinery within the last few years, and from the viewpoint of economical operation and uninterrupted service the late machines are far superior to the old. The engineers of the refrigeration plants equipped with modern apparatus have a soft snap as compared to those who are almost wet nurses to the antiquated engines and compressors still found in many plants.

A number of years ago I was employed as an engineer in a large creamery plant which consisted of a number of boilers and engine-driven ammonia compressors. These compressors were twin-cylinder upright machines of an antique type. Owing to poor design they proved to be the most difficult and troublesome machines to operate in my experience. The suction and discharge lines were connected to the cylinder heads, and when it became necessary to remove the heads, it was impossible to do so without dismantling both the suction and discharge pipes to the compressor. The cylinder-head gaskets were but $\frac{5}{16}$ in. wide and were a continuous source of trouble due to leakage and blowouts. Every kind of gasket material on the market was tried on these cylinder heads with no avail. At the time these compressors were built, false heads were unknown, and a small amount of liquid coming back to a machine was sufficient to loosen the head or blow out a gasket.

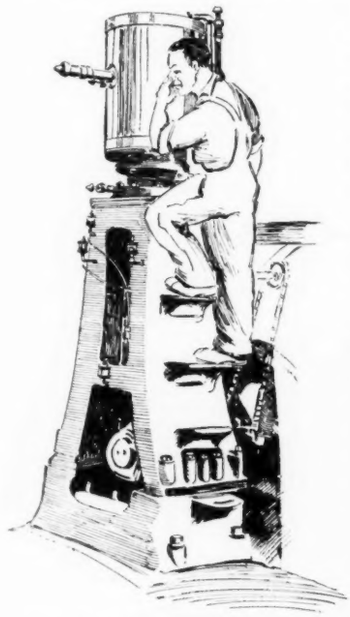


Fig. 1—A leaky heat gasket soon made itself felt

The cylinders were cooled by an open water jacket, the water level extending above the cylinder-head gasket. In case of a small leak in the gasket it was likely to be unnoticed until the water was tested with litmus paper, but a large leak made even the jacket water smell. A great deal of ammonia was lost in this manner. Owing to the numerous shutdowns and interrupted service the management finally decided that these machines had served their period of usefulness. Consequently, two up-to-date compressors were installed and operation of the plant was a pleasure instead of a nightmare.

We also noticed a great reduction in the ammonia and lubricating oil used in the new machines, the saving in ammonia being due to the absence of leaks around the cylinder heads. The new machines were equipped with false heads, and a small slug of liquid coming back to the chine would pass through without trouble. The saving in lubricating oil was due to the inclosed crankcase, for there was no chance for the oil to be thrown or leak out. I was with this plant for three years after the new machines were installed, and except for an occasional change of oil in the crankcase they operated continuously without repairs or trouble of any kind.

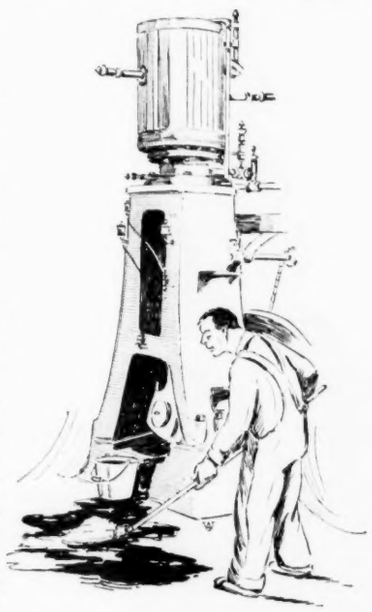


Fig. 2—The engineer became an expert mopper

At another time, in a different plant, I had a somewhat similar experience with a small compressor of old design, which was lubricated entirely with sight-feed oil cups. Most of the bearings were badly worn, and as the builder had gone out of business, it was impossible to secure spare parts. Because of the worn bearings and open crankcase it was very wasteful of lubricating oil, requiring at least two quarts a day to keep it in operation. The worn bearings and open crankcase caused it to throw oil in every direction. The piston rod was so badly scored that we decided to junk the machine. A new modern machine was installed, and we were greatly pleased with it. An inclosed crankcase and automatic oiling system saved a great amount of oil and cut the ammonia bill in half.

A number of years ago, while employed by an ice company, we had occasion to install a 100-ton ammonia compressor. The machine selected by the company

officials was a horizontal, double-acting motor-driven outfit. While the installation was in charge of an erecting engineer employed by the compressor manufacturer, as is usually the case, the plans were submitted to the chief engineer and he was asked whether he had any suggestions or objections to make. The motor was connected by a short belt drive to the compressor flywheel while a weighted idle pulley was used to tighten the belt and give it the proper arc of contact on the motor pulley. I do not remember the weight of the idle pulley, but should judge it to be between 300 and 400 lb. The chief engineer objected to this part of the arrangement, arguing that the weight of the idle pulley combined with the weight and tension of the belt would cause abnormal strain and excessive friction on the motor bearing on the pulley side of the motor. The chief engineer voiced his objections and suggested to the erecting engineer that an outboard bearing be used on the motor shaft to relieve the motor bearings of the extra load. The erecting engineer scoffed at the chief's suggestion and refused to consider it. Thereupon the chief filed with the management a written recommendation outlining his criticism and his proposed method of remedying it, so that he would be on the safe side in case of trouble.

Starting the Outfit

A short time later the foundation for the new machine was poured, and within a few weeks the compressor and motor were installed. When the unit was started, by agreement the erecting engineer manipulated the hand lever on the compensator which started the motor. Everything appeared to be O.K., the motor and compressor came up to the regular speed and operated smoothly. The compressor suction was opened, and the machine was put on the line to do its share of the work.

A few minutes later the chief engineer placed his fingers on the motor bearing on the pulley side, then he stepped around to the other side of the motor and again placed his fingers on the opposite bearing. The erecting engineer was standing near-by, and the chief reported to him that the motor bearing on the pulley side was getting warm. The erecting engineer walked over and felt of the bearing. A look of alarm spread over his face, but he was not ready to admit that he was whipped.

He ejaculated, "It's a little warm, but I guess it'll wear in in a little while. Probably it's a little tight, being new. Maybe I'd better use a heavier oil on that bearing."

A Hot Bearing Shows Up

To shorten this narrative, about twenty minutes later you could fry eggs on this bearing and it was necessary to shut down the machine. Every grade of oil was tried to no avail. The erecting engineer even attempted to keep the bearing cool by applying wet bags to the outside of the bearing. It was possible to run the machine for only about twenty minutes when it had to be shut down for two hours to allow the bearing to cool. Finally, the machine was allowed to run a little longer than usual as an experiment, consequently the bearing got so hot that it scored the shaft and the overload relay cut out the compensator.

This put a stop to the experiments, and the erecting engineer admitted that the machine would not operate under present conditions and wired the manufacturer for instructions. They investigated the trouble, finally dismantling the motor and shipped the armature and shaft back to the motor manufacturer who supplied a longer shaft and an outboard bearing for the motor, as originally recommended by the chief. Thereafter the motor bearings ran cool and no further trouble was experienced.

A minor trouble was had with the packing gland on this same compressor, due to careless operation of the engineers. The double-acting compressor had not only a main valve on the suction line, but also auxiliary valves on each branch of the suction line running to opposite ends of the cylinder. The advantages claimed for this type of construction are that one of the auxiliary valves may be closed and the compressor operated single acting at times when only a small refrigerating capacity is required. When full capacity is needed, both suction valves can be opened.

What Caused the Hot Rod

One cool day when the temperatures were low and the suction pressure was below 15 lb., the operating engineer decided to reduce the capacity of the machine by shutting off the auxiliary suction valve on the front end of the cylinder. A few minutes later he noticed that the piston-rod packing gland was smoking. He immediately slacked up on the gland and reported to the chief, who investigated and again opened the suction on this end of the cylinder; in a few minutes it was back to normal temperature. The gland was packed with metallic packing; closing the suction valve had prevented the cool or saturated ammonia gas from coming into contact with the rod and packing gland, consequently, its temperature had immediately started to rise and expansion of the packing had helped it along. The operating engineer had noticed it just in time, otherwise the rod would probably have been damaged or the packing ruined. Thereafter, when the machine was operated single-acting, the rear end of the cylinder was shut off and the machine gave no further trouble.

There are only two ways in which a force can be exerted on a body, 1, by physical contact with another body that pushes or pulls it, or, 2, by the action on the body of some field of force in which it lies, such as a gravitational field or a magnetic field. Aside from these two sources, there are no real forces. For example, consider a body swung in a circular path on a string. What forces are acting on it? Just two,—its weight, because it is in the gravitational field of the earth, and the pull of the string toward the center. But what about the centrifugal force? There isn't any such force in a reality. If the string broke, the body would move in a straight line tangent to its present circular path, modified, of course, by gravity. It would not move straight out from the center of rotation. The only reason that it now travels in a circle is that the pull of the string makes it do so. Its motion is constantly being altered from the straight line in which it would move if unhampered. The body moving in a circular path is not in equilibrium; the forces acting upon it are not balanced. But some believe that it is easier to solve problems of this sort by introducing a fictitious force, the so-called centrifugal force, pointing straight out from the center, and equal to the pull in the string. Including this imaginary concept balances the forces so far as the rotation is concerned. Curiously, there is no corresponding custom of introducing an imaginary "force" to balance gravity. It would lead to clearer thinking if imaginary forces were less frequently introduced in other cases of actually unbalanced forces.

Answers to What Do You Know

The questions are on page 206

Ans. 1—When the compression is over a moderate range the work is less when the process is adiabatic, but when compressing to a high pressure the work is less with isothermal compression.

Ans. 2—The water vapor at exhaust carries out of the cylinder its latent heat and its superheat. This amount of heat is considerably greater than that contained in the same weight of combustion gases or excess air. There is a theoretical thermal loss. Practically, there is a gain, for the water holds the compression temperature below the ignition point and the engine will operate without pre-ignition at a higher compression pressure.

Ans. 3—When an engine uses steam at a high superheat, little moisture exists on the walls and consequently the oil film is not washed away as in case of a saturated steam. The film remains on the wall, and, being exposed for a long period to a high temperature, decomposition may set in unless the oil is a filtered stock from which the free bitumen particles have been removed. With saturated steam a non-filtered or dark cylinder oil is more suitable, being more viscous.

Ans. 4—Letting 100 per cent equal the stroke volume, the total volume of steam at cutoff is $\frac{3}{8} + 0.06 = 0.44$ of the stroke volume. The total cylinder volume is the stroke volume + clearance volume, or $1.00 + 0.06 = 1.06$. The number of expansions is thus $1.06 \div 0.44 = 2.41$.

Ans. 5—As the pressure increases, the amount of heat necessary to evaporate a pound of liquid decreases until a pressure point is reached where no latent heat of evaporation is needed and the liquid at this pressure contains as much heat as does the saturated vapor at the same pressure. This is called the critical point and for water is 3,200 lb., giving a saturated temperature of 706 deg. F. At this point the densities of water and of steam are identical.

Ans. 6—In connecting the outer shell of a Manning boiler furnace to the main boiler shell, which is of a smaller diameter, an S-curved circular sheet is used; this is called the Ogee joint.

Ans. 7—Diversity factor is equal to the sum of the maximum demands of the individual loads on a system divided by the maximum demand of the group for any short period.

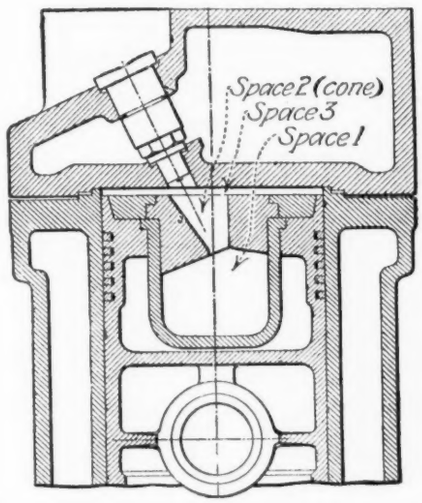
Ans. 8—At present, it will average 4 horsepower per ton, but this means an overpowered plant and the tendency is toward a lower ratio.

Ans. 9—Yes. The force along the rod is the resultant of the load on the piston and the reaction at the crosshead. What the force along the rod amounts to depends upon the rod-to-crank ratio and the position of the crank, with a given cylinder and steam pressure.

Ans. 10—John E. Sweet, who died 1916, was Professor of Mechanical Engineering at Cornell, President of the American Society of Mechanical Engineers in 1884, and was best known as the designer of the Sweet Straight-Line Engine.

The Acro Diesel Engine

A NOVEL Diesel engine was discussed in a paper read by Dr. Ing. R. Stribeck before the Verein Deutscher Ingenieure. The characteristic which differentiates the Acro from standard Diesels is the peculiar combustion space. This, as may be seen from the illustration, is made up of a cavity contained within the piston body and communicating with the small cylinder clearance by means of a nozzle-shaped passage. The fuel jet is directed into the combustion space, the jet flowing along the axis of the nozzle passage. While the designer pointed out in his paper that the arrangement was unlike



Combustion cavity of the Acro high speed Diesel

that of the precombustion solid-injection Diesel, it would appear that it is but a modification of the old-type semi-Diesel, the cavity being removed from the cylinder head to the piston body.

The design undoubtedly does bring about a thorough mixing of the fuel and air. The oil spray passing along the nozzle passage has a flow in the same direction as the air which passes into the chamber from the cylinder space. This convenient flow gives a more desirable turbulence than a contra flow.

Tests run on an engine so equipped and designed for high-speed operation were satisfactory from the viewpoints of fuel consumption and mean effective pressure.

THE STOPCOCKS OF AN ORSAT frequently give trouble by sticking. This trouble is experienced more often when the orsat is operated near the boiler where the temperature is high. To keep the stopcocks in good condition they must be well lubricated. For this purpose ordinary vaseline is not suitable as it is too light. A good lubricant may be made of a mixture of pure rubber, beeswax and vaseline. It may be bought from a supply house or prepared by melting one part of pure rubber in a suitable container, adding one part of beeswax, and then adding to this mixture vaseline until the grease has the proper consistency. Grease prepared in this way may be made to suit the temperature conditions under which it is expected to be used. It is best applied frequently but sparingly, care being taken to see that none gets into the stopcock bore.

EDITORIALS

F. R. LOW, *Editor*

Record Keeping in Small Plants

THE engineers of many of our smaller power plants seem to depreciate the value of any systematic method of keeping power-plant records and accounts. These men state emphatically that such records might be satisfactory and necessary in large plants, but that, in their opinions, they are uncalled-for refinements in small plants. May it not be that these men do not know how to collect the data necessary for a simple set of records and do not know how to make use of them after they have been collected and recorded?

The size of plant is absolutely no excuse for not having some method or plan of "keeping books." Even in the smallest of plants it is possible for the engineer to maintain a record of such items as the coal burned and the steam made. An ordinary platform scale, a water meter, a few draft gages, some thermometers, together with the interest and determination of the engineer, will enable him to get a good approximation of what his plant is doing and will help him in locating the places where waste may be prevented. Information of this kind supplies effective support to any requests for additional equipment, improvements or instruments for improving plant operation. In addition, such records are occasionally life savers for the isolated plant when the representative from the central station comes around.

The days of keeping records on shingles or the backs of shovels have passed. An important part of the job of the engineer, in a plant of any size, is to collect the data for and to maintain, as well as he can, a record of his plant costs and performance. The experiences of thousands of small plants throughout the country prove that record and cost keeping pays big dividends.

Letting the Men in on the Costs

THE chief engineer of a fairly large mill power plant, in a recent conversation relative to increasing his plant efficiency, emphasized the importance of keeping the men in the plant well informed about the various costs and economic phases of maintaining and operating the plant. No doubt, this same matter has been given some thought by the managements of many other plants in which it has sometimes been found difficult to obtain the whole-hearted interest of the men, especially of the firemen, in any efforts to reduce the costs of steam and power.

Such a plan of placing cost records and also other economic features of plant operation before the men in the plant for discussion and suggestion has many good points. With a knowledge of plant costs and the part he plays in creating these costs, the man in the plant gets an entirely new viewpoint of his job. He appreciates the fact that the plant isn't merely a place for burning coal, generating steam and producing power, but an economic unit of the mill or enterprise in which the finances are quite as important as the engineering. Instead of seeing coal being swept into the ashpit, he sees real money. He learns just why such boiler-room sports as throwing a chunk of coal through a window, smashing an electric globe and breaking a scoop handle by using it as a bar, increase the cost of steam, heat or power and make it more difficult for the plant to make progress, and perhaps for himself to improve his own conditions or compensation.

A knowledge of the economic features of their jobs by the men in the plant will result in a decided improvement of conditions, and will be advantageous to the men and the management as well.

Mixing Burners for Pulverized Coal

ENGINEERS are quite generally reaching the conclusion that the best combustion of pulverized fuel is more dependent on the proper design of burners than on furnaces. This was not fully realized on many of the earlier designs where huge furnaces with large refractory walls were provided to secure complete combustion. Long flame paths are still considered necessary with certain designs to secure the proper mixing of secondary air with the flame.

It has been found difficult in many furnaces to secure a proper distribution of secondary air at all loads where long flames are used. This has led to a more intensive study of mixing burners, which have been advocated for some time by some who have given careful study to the problem.

In the mixing burner the pulverized coal carried by the primary air is thoroughly mixed with the secondary air before leaving the burner. Preferably, the secondary air should be highly preheated. This mixture ignites rapidly, burns with minimum flame for the given coal

and load conditions and can thus utilize furnace volume more effectively than the earlier burners. Ignition is also independent to a considerable extent of the nature of the furnace walls, so that extensive water cooling may be employed.

Care and study must be devoted to the design of these new burners to insure thorough mixing without segregation of the coal in certain parts of the mix. The furnace must be so proportioned that the flame can expand properly. Furthermore, the flame travel in the furnace must permit complete combustion of the coal particle before it enters the boiler tubes.

Much may be expected of the newer mixing burners in improving the combustion of powdered coal.

Safe Operation of Elevators

ALTHOUGH an elevator car hangs from the end of a cable and travels vertically, it has proved to be the safest means of transportation. The modern passenger elevator has established this record notwithstanding that it is frequently in the hands of incompetent operators and not properly maintained. Accidents do happen on elevators, in which people are seriously injured or killed, but these accidents are, for the most part, preventable by the installation and maintenance of proper safety devices.

Practically all serious accidents on elevators occur at the landing doors or are due to the car gate being open. By interlocking the car gate and landing doors with the control in such a way that the car cannot be started unless these are closed and locked, these accidents can be prevented. In some states the installation of such interlocks is made mandatory by law. Unfortunately, in others this is not the case, and in these states the accident rate is much higher than in those that require landing-door and car-gate interlocks. Considering the attention given to safety in industry and what has been accomplished in accident prevention, one might raise the question, Why have interlocks on elevator landing doors not been more generally adopted?

The objection is sometimes raised that the use of door interlocks slows up the operation of the elevator. This is probably true if dangerous operation is allowed. An elevator car that is started from a floor before the landing door is closed and locked is a hazard to human life, since someone may attempt to hold open the door and board the car. Or the door may be left partly closed and the car run away from the floor, in which case there is danger of someone walking into the hoistway. There are plenty of such accidents on record to show the seriousness of this hazard. So far as the safe operation of the car is concerned, proper landing-door interlocks help speed up the car's operation, since the operator can handle the control to move the car the instant the door closes and locks, something that cannot be done with safety without interlocks.

Door and gate interlocks, like any other safety devices, are effective as long as they are properly maintained. A gate switch plugged so that it cannot open, or the interlock switches short-circuited by the emergency button, are worse than none. Many of the accidents that occur on elevators are on those equipped with protective devices that have been made ineffective. Elevators can be made practically safe to operate under all conditions, but they must be equipped with the proper safety devices and these must be maintained in working condition.

Geared Versus Electric Drive

WITH the Geneva Conference occupying the front pages of the daily newspapers, and announcement that contracts have been let for four more ten-thousand-ton scout cruisers, naval matters take on special significance. To engineers particular interest centers around the propelling machinery of these fast scouts, each with a capacity comparable to a good-sized central station; that is, over a hundred thousand horsepower.

Since the unquestioned success of electric drive, from the viewpoints of both economy and flexibility, and its general adoption on all the later capital ships, many will wonder at the action of the Navy Department in reverting to gear drive for these latest additions to the fleet.

The tremendous power in these ships will, of course, be called upon only when driving at top speed—a condition seldom met. For ordinary cruising speeds about one-eighth to one-tenth the maximum power will be required, since the power increases as the cube of the speed.

In order to avoid idle propellers acting as a drag on the ship, it will be necessary to drive all four shafts, even at the cruising speeds. Thus, with geared units each of the four turbines will be run at an extremely light load—a most uneconomical operating condition. On the other hand, with electric drive the cruising power to the four shafts could be supplied from one turbine at an economical point on its load curve.

Why, then, was this economy sacrificed in laying down the plans? The answer appears to lie in certain terms of the Washington Conference a few years ago. At that time the maximum tonnage of cruisers was put at ten thousand tons, but this limitation failed to include fuel and water. The machinery for electric drive is considerably heavier than that for gear drive; hence by selecting the latter it was possible to build a slightly larger ship. Obviously, either some of this increase must be taken up in carrying more fuel or the cruising radius will be cut down. The wisdom of sacrificing operating efficiency must be balanced against advantages of the larger ship from a military point of view. On this point there is bound to be a difference of opinion.

The basic principles are the same on land and sea. The plant must deliver maximum results for minimum cost. Simple efficiency for certain conditions of load cannot determine the plant design.

IDEAS *from* PRACTICAL MEN

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How a Control Circuit May Damage Its Indicating Lamps

MUCH effort is sometimes expended in laying out remote control circuits to eliminate as many wires as possible, in order to produce the simplest and most economical wiring scheme. A frequent trouble occurring in an improperly designed simple circuit is the burning out of indicating lamps, and in many instances the main cause—trip coil discharge—is overlooked in checking for defects.

Indicating lamps in control circuits for moderately large circuit breakers may be energized through the trip coils, but for small breakers such as field switches, in which the trip mechanism responds to weak currents, the lamp will often require enough current to trip the breaker. In this case a small auxiliary relay is sometimes placed on the switchboard and energized from the trip circuit, as it requires only a small current; however, it is generally

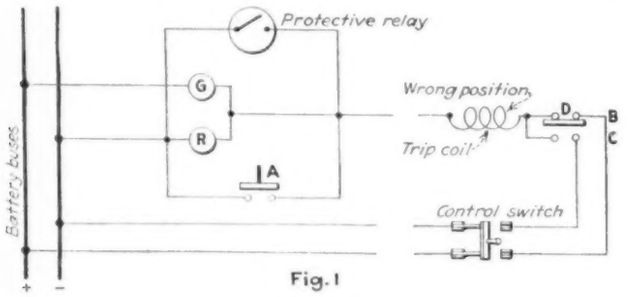


Fig. 1

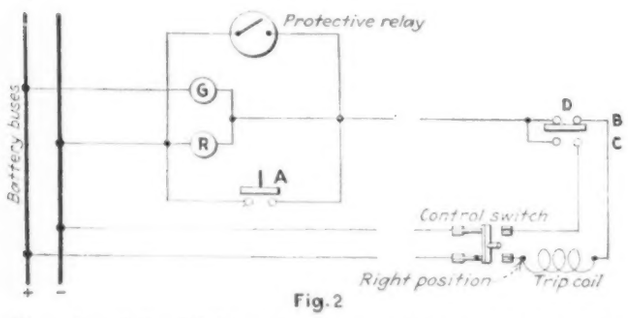


Fig. 2

Figs. 1 and 2—Right and wrong positions of trip coil for protection of indicating lamps

less expensive to use an extra wire to bypass the lamp current around the trip coil.

Figs. 1 and 2 illustrate a two-lead control system—one lead for closing the breaker and one for tripping. The closing lead is not shown. In Fig. 1 the trip coil is placed in such a position that its discharge may burn out the lamps when the breaker opens. Fig. 2 indicates the correct location. In Fig. 1 both indicating lamps are energized through the trip coil. When the breaker closes, pallet switch *D* will be in position *B* and the red lamp will light. For tripping, the red lamp is short-circuited at *A* by a control switch, and full current flows in the trip coil. When the breaker opens, the green-lamp circuit is completed at position *C* of the pallet switch, which allows the trip coil to discharge through the indicating lamps provided *A* has been released. This is usually the case in push-button systems, *A* being released when the red lamp goes out, and the discharge must follow the lamp circuit. To eliminate this trouble, the trip coil should be connected as shown in Fig 2, so that its circuit is broken upon tripping and remains open until the breaker is closed again.

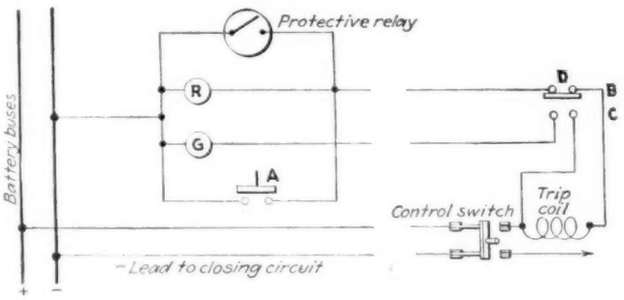


Fig. 3—Use of additional control wire, eliminating some disadvantages of the circuit of Fig. 2

This system possesses two disadvantages that cannot be corrected without the use of another wire. Should the trip mechanism fail to operate when a protective relay closes the circuit, the red lamp would be short-circuited and the green lamp energized, indicating that the breaker was open when it was still closed. Even if no equipment was damaged, the trip coil would be burned out if the fault was not found in time. Also, when the control switch in the circuit is opened, the two lamps will be in series and burn with equal brilliancy, causing confusion at the switchboard.

In the system of Fig. 3 both the foregoing troubles are eliminated by the use of an extra wire to the pallet switch. The only disadvantage of this system is that both lamps are dark during the interval taken for the breaker to open. A third wire would be required to overcome this, but the advantages of the trip coil being in the red-lamp circuit would be sacrificed. The red lamp furnishes a check on the proper operation of the pallet switch and on the trip coil connections, as well as indicating when the breaker is closed.

Los Angeles, Calif. E. H. STIVENDER.

Has Vacuum Cleaner in the Plant

A HOME-MADE vacuum cleaner recently installed in a power plant has proved to be well worth the labor of putting it together.

An ordinary ejector was used. This had the 1½-in. suction line run on top of the boilers and around the fire and engine rooms, with outlets at various points.

Cleaning with a vacuum hose

These were provided with valves and connections for attaching the suction hose, which was part of a house vacuum cleaner.

Air was used instead of steam for working the ejector, and the discharge was piped into the base of the 110-ft. chimney, where all the dust, etc., was delivered and carried away. With this method the cleaning of the plant is done in one-half the time formerly taken and with less annoyance from sweeping. THOMAS M. STREET.

Wilkes-Barre, Pa.

Why Read Instruction Books?

INSTRUCTION books giving detailed information on the assembly and operation of electrical equipment are ordinarily furnished when there might exist any uncertainty as to correct procedure. It often happens, however, that because of misinterpretation or failure to read the instructions, trouble develops and the apparatus is unduly criticised.

To cite a particular case, I once investigated a high-capacity electrically operated outdoor-type oil circuit breaker. This breaker had been in service approximately two years, but had given trouble from the start and the engineering staff in charge had been unable to locate the fault. The trouble reported was that it required three or four attempts before the electrically operated mechanism would finally latch the breaker in the closed position. As a result the piece of apparatus was making a poor showing as compared with a competitor's equipment which was installed adjacent to the faulty breaker.

Upon my arrival at the location, and after each member of the staff in the plant had amply expressed himself as to the relative qualities of the two pieces of equipment, an investigation was started. The breaker was taken out of service for inspection, and according to reports it did fail to latch on the first three attempts. It was soon noticed, however, that the valve on the air cushion was practically closed. A turn of the adjusting screw allowed the valve to release the air promptly, and the breaker latched perfectly with the first attempt. If the men on the job had read their instruction book, they could have made this two-minute adjustment, saving them two years of anxiety and preventing unwarranted adverse criticism of the breaker. W. J. BELL,

Chicago, Ill. Westinghouse Elec. & Mfg. Co.

Safe Method of Removing a Boiler Tube

I RECENTLY stepped into a boiler room and found the engineer engaged in removing a boiler tube. The method employed was simple and effective, and was about as follows:

He first used a splitting tool, shaped about as shown by Fig. 1, and split the tube for a distance of 2 in., starting at a point just beyond the tube sheet, as shown. Having split the tube the required distance he used a flat chisel to cut the beaded portion of the tube away from the sheet. Next, an oval tool similar to that shown in Fig. 2, was driven between the tube and the tube sheet

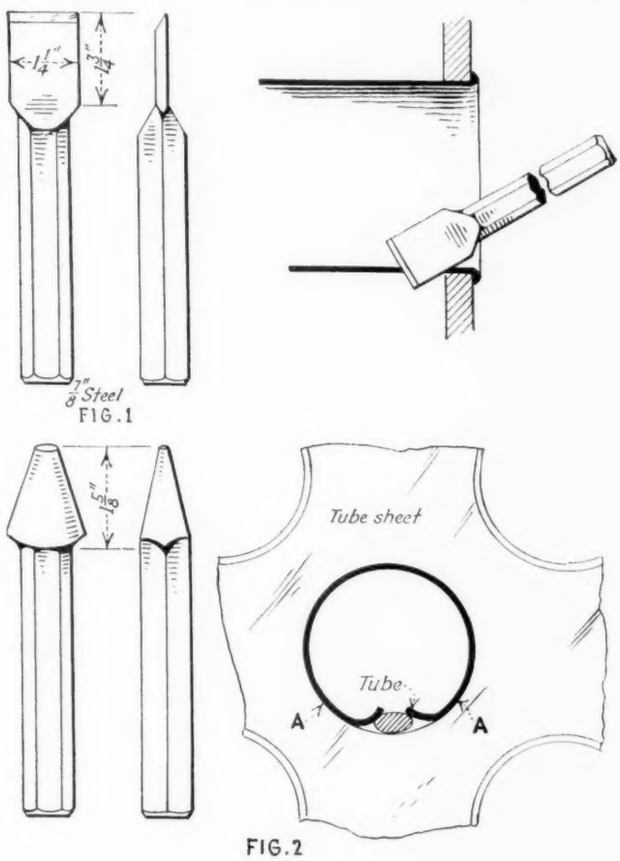


FIG. 1

FIG. 2

Tool for removing tubes from return-tubular boiler

at the point where the tube had been split. This forced the edges in, as shown, and then the tool was used to drive the wall of the tube in at a point on each side of the slit, at the points *AA*.

This made the tube small enough to permit its being drawn through the sheet. As the rounded side of the tool was practically the curvature of the hole in the tube sheet, there was no danger of damaging the sheet.

Atlanta, Ga. J. W. RIGHT.

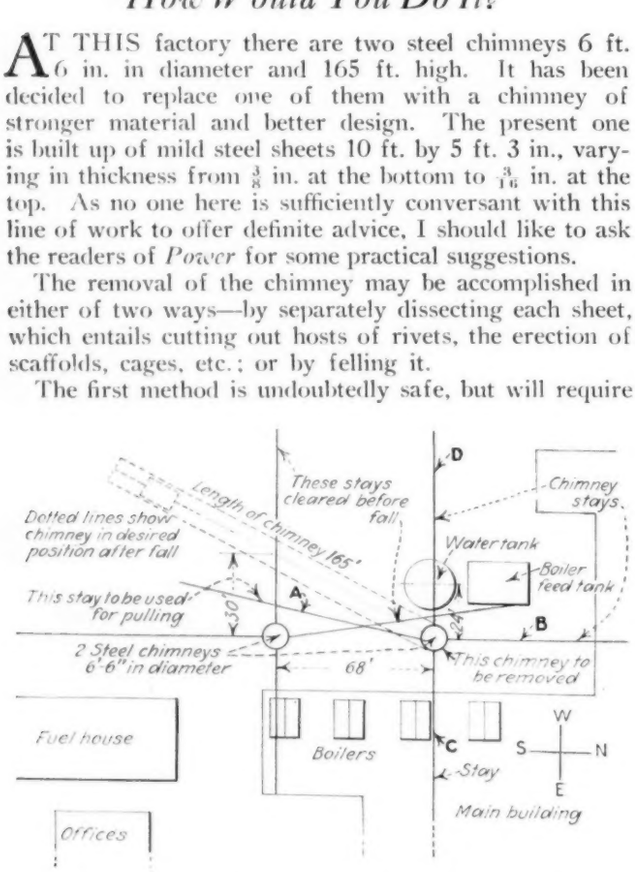
COMMENTS *from* READERS

How Would You Do It?

AT THIS factory there are two steel chimneys 6 ft. 6 in. in diameter and 165 ft. high. It has been decided to replace one of them with a chimney of stronger material and better design. The present one is built up of mild steel sheets 10 ft. by 5 ft. 3 in., varying in thickness from $\frac{3}{8}$ in. at the bottom to $\frac{3}{16}$ in. at the top. As no one here is sufficiently conversant with this line of work to offer definite advice, I should like to ask the readers of *Power* for some practical suggestions.

The removal of the chimney may be accomplished in either of two ways—by separately dissecting each sheet, which entails cutting out hosts of rivets, the erection of scaffolds, cages, etc.; or by felling it.

The first method is undoubtedly safe, but will require



Plan showing position of chimney relative to surrounding objects

considerable time which to us is valuable. The second method is short but involves certain risks, as to extent of which I am hoping some reader will enlighten me, because this is the course I should like to adopt. At the same time I am anxious to raze the chimney with as little damage as possible.

The sketch shows the general location of the chimney in relation to buildings, water tanks, etc.

My plan of tackling the job would be first to cut about three-quarters the way around the base with the gas torch and to bolt a strap of 2 x $\frac{5}{8}$-in. flat bar across the kerf at right angles about every eight or nine inches as the cutting progressed. These straps would support the stack temporarily and prevent any settling due to the kerf. Next the south stay *A* would be lengthened and passed through a single sheave block fixed to the ground a distance farther away from the base than the length of the chimney and in the direction of the fall. When all is prepared, the north and east stays *B* and *C* will be slackened and with the slightest strain on the south stay *A* the straps around the kerf will be loosened, the west stay *D* remaining fixed; the rest remains to the men on the south stay. The lower part of the chimney above the kerf will be securely tied with rope and stayed to prevent any rolling after the fall.

Practical suggestions from readers of *Power* experienced in this line will be much appreciated.

Kingston, Jamaica. RONALD SIMMONS.

* * * *

Increase in Cylinder Oil Consumption Due to Boiler Compound

IN READING the reply of A. Maiers in the June 14 issue to Mr. Foley's inquiry in the April 26 issue as to the increase in cylinder oil consumption when compound is entrained in the steam, it occurred to me that my experience along this line might be of interest to some readers.

The belief among engineers that soda ash is a suitable compound for practically all waters is a serious mistake. In my opinion the best way to find the proper compound to use in a boiler is to have an analysis made of the feed water. An analysis should be made of a sample of the water from the well, lake or river from which the supply is taken and also of the feed water from the hotwell or receiver tank before it enters the feed pump. This will show the amount of cylinder oil contained in the feed water. In case the exhaust steam from the engines and feed pumps is used in the heating system, a compound can be obtained that will dissolve the scale-forming impurities and also neutralize the cylinder oil in the returns. If the feed water is of a muddy content, the boiler should be blown out at frequent intervals to remove the thick sludge. But if the water is carried at a high level and the boilers are operated at high ratings, priming is likely to occur, which in turn will destroy the oily film on the walls of the cylinder and calls for an excessive feeding of cylinder oil. Hard water produces a hard scale formation on the tubes and plates and often contains much mineral lime, which is hard to remove and dissolve in a manner that will not destroy the lubrication in the cylinders, but there are compounds available that will relieve the most severe case if they are used properly.

If it is not possible to have an analysis made of the feed water, the proper compound may be selected by experimenting with the quantity of each kind and watching its effect on the scale in the boiler and the effect on the lubrication of the cylinder and selecting the one that seems to produce the best results in both places. Often, a compound that removes scale in the boiler, will seem to destroy the lubrication in the cylinder. But not infrequently, a compound is blamed for the poor lubrication of the engine, when in reality it is due to the poor grade of cylinder oil being used.

When soda ash is used to excess in a boiler, it will eventually form a scale of its own which will stick to the tubes and plates. This can be removed by reducing the amount fed and by blowing down frequently for a few weeks until the scale disappears. It is, in my opin-

ion, bad practice to put compound into a boiler while it is being operated, as soda ash, if there is much sludge on the top of the water in the boiler, will tend to cause violent foaming. The better way is to put the compound in the feed-water tank or receiver at night so that it will be fed to the boiler gradually when pumping the boiler up for the night or when the load is the lightest. Or better still, put the soda or compound in when the boiler is cut out of service to be cleaned and boil it out before draining.

Some compounds will remove scale from the tubes of return-tubular boilers in long strips, and these strips will fall down on the tubes beneath and shell over the fire to rebake on the plate and girth seam. I had one case of a return-tubular-boiler where the tubes had become matted together with scale except between the tubes in the center and between the outside tubes and the shell. It required the use of considerable soda to remove the scale and the engine developed a groan. Finally, after experimenting with a number of compounds I found one that dissolved the scale into a form of mud that could be easily washed out with a hose and did not appear to affect the lubrication.

The whole subject boils down to the proposition of using the right quantity and quality of cylinder oil and selecting the right compound for the particular water used.

R. A. CULTRA.

Cambridge, Mass.

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The High Cost of Cheap Oil-Engine Operators

WITH reference to the article in June 28 issue on "The High Cost of Cheap Oil-Engine Operators," by A. W. Newell, from my experience I feel that the author is 100 per cent correct in his statement.

Some time ago I was called upon to administer first aid to a 75-hp. 3-cylinder, two-stroke-cycle solid-injection oil engine that refused to start. After looking things over and asking a few questions, I found that the engine was operating 16 hours out of 24. The altitude was high, and the nights were cool at that time of the year. The operator, upon trying to start up in the morning, found that with a full tank of air the engine would just turn over.

After some more questions I learned that when the engine was running best the exhaust was a very white color on the starting cylinder. I also found that the fuel oil was somewhat heavy for that type of engine, especially at the altitude at which it was working. Upon taking the head off the cylinder No. 1, which was the starting cylinder, I found the piston to be almost frozen solid with a tar-like substance. After giving it a good bath with kerosene oil, we managed to pull the piston. It was seen that the piston was in good shape, so after cleaning we put it back. When everything was ready to start, the operator lighted the heating torch that was on each cylinder. The engine, being a low-compression type, required heating of a plug before starting. In about five minutes he cut out the torch on No. 1 cylinder and I asked him why he did it. "The thermometer is getting too high on that cylinder," he said, "the book says the temperature should never go above 120 to 140 deg. F., and it is now past 120 deg. F."

I told him to light the torch again and leave it on until I told him to give her the air and then to keep it on until I told him to take it off.

He did so, but with one of those wise looks as if to say, "Hop to it, old man. You will see if it doesn't ruin the engine." The engine started off in fine shape and operated perfectly.

The whole trouble was, he had been running the engine on two cylinders, the load being very light, and after shutting down, the fuel and lubricating oil, getting cold, formed a sticky tar-like substance that completely froze No. 1 cylinder. I gave him, and especially the manager, some advice concerning the engine, and as far as I know they had no more trouble. This was just another case of "Start them up, lock the door, give them plenty of water and oil, and they will run."

W. P. GIBSON,
Hydro-Power Plant.

Roosevelt, Ariz.

* * * *

The Influence of Velocity Head on the Selection of Centrifugal Pumps

IT IS customary for pump manufacturers to base their efficiency guarantees on the water horsepower as determined by the total developed head, which includes pressure head, elevation head and velocity head. Velocity head is usually overlooked and often misunderstood by the pump user, though it is easily calculated from the simple equation $h = \frac{V^2}{2g}$.

The velocity of the fluid as it enters the suction nozzle or leaves the discharge nozzle is determined by dividing the flow in cubic feet per second by the cross-sectional area of the nozzle in square feet. If the areas of the suction and discharge nozzles are equal, there is no velocity head to be considered, but if one is larger than the other, the difference in velocity head is added to or subtracted from the pressure head according as the discharge nozzle is larger or smaller than the suction nozzle. From the viewpoint of energy transfer to the water in the pump, the theory is entirely correct, but it can lead to considerable error in evaluating the pump's practical utility as will appear from the following example.

Suppose that bids are asked on a pump 18 in. nominal size to deliver 9,000 gal. per min. against 35 ft. head, and that one manufacturer, figuring on a pump with 18-in. suction nozzle and 18-in. discharge nozzle, guarantees 82 per cent efficiency (efficiencies slightly higher than this have been obtained) while another manufacturer offering a pump having a 18-in. suction nozzle and a 16-in. discharge nozzle guarantees 82.5 per cent. Which is the better pump, other things being equal? It is assumed that on test each pump will show exactly the efficiency guaranteed. The pump with the higher efficiency has received credit for a velocity head of $\frac{(14.4)^2}{(64.4)} - \frac{(11.4)^2}{(64.4)} = 1.2$ ft., 11.4 ft. per sec. being the velocity in the suction nozzle and 14.4 ft. per sec. the velocity in the discharge nozzle.

If there is space enough to install a straight 16x18-in. increaser, from 60 to 70 per cent of the velocity of the water as it leaves the pump may be converted into useful pressure head. It will not in general do to have the entire discharge piping of 16 in. diameter, as that would lead to excessive pipe friction; in fact, in practically all cases it should be larger than 18 in. The useful pressure head obtained from the velocity head is 70 $\times$ 1.2, or 0.84 ft. and the net loss is 0.36 ft. or about 1 per cent of the total head. The over-all efficiency becomes 99 per cent of 82.5, or only 81.67 per cent, as compared

with 82 per cent guaranteed for the pump having the 18-in. discharge nozzle.

In probably 95 cases out of 100, the pump will be installed with the discharge flange bolted directly to an elbow to connect with a pipe extending vertically upward to the ceiling or downward through the floor. The friction of a 90-deg. ell is commonly figured as equal to that of 50 ft. of straight pipe, on which basis the pump with the 18-in. discharge nozzle will have a loss through the elbow of 1.63 ft., while the pump with the 16-in. discharge nozzle will have a loss through the elbow of 2.85 ft. The loss with a 16x18-in. increasing ell would be almost as great, because there would be practically no conversion of velocity to pressure in the elbow. There is accordingly an increased loss due to the use of the 16-in. discharge nozzle of 2.85 ft. — 1.63 ft. = 1.22 ft., or 3.48 per cent of the total head developed. Based on readings taken at the outlet of the ell, the pump having the 18-in. discharge nozzle has a useful efficiency of $\frac{35 - 1.63 \times 0.82}{35} = 78$ per cent, while the pump with the 16-in. discharge nozzle has a useful efficiency of only $\frac{35 - 2.85}{35} \times 82.5 = 75.7$ per cent.

In other words, the customer, when comparing efficiencies, should consider the complete installation, including the piping arrangement that will be used with the pump, and he should bear in mind that a pump having the proper size of nozzle may give a greater useful effect, even though its guaranteed efficiency is lower. This applies particularly to low-head pumps, where the velocity head constitutes an appreciable part of the total head.

GEO. H. GIBSON,
New York City. Geo. H. Gibson Co.

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Power Plant Equipment Obsolescence

THE editorial on the subject of obsolescence in the June 14 issue applies forcibly to the average industrial plant, but a point not brought out is whether it is the equipment or the operating methods that are obsolete. I have seen many generating units scrapped because they were considered inefficient, but it was the application, not the design or condition of the power units, that caused inefficiency.

A paper mill shut down its main engine, a single-cylinder Corliss that ran condensing. The reason given for this was that the paper machine engines supplied nearly enough exhaust for drying paper. About 15,000 lb. of process steam per hour was used, 7,000 lb. at 10-lb. pressure and 8,000 lb. at 50-lb. pressure. The main engine used 8,000 lb. per hour at a load of 420 hp., and as one boiler out of the three was in bad condition, power was purchased, with the exception of that required for the paper-machine drive. By retaining the small engines on two paper machines to generate by-product power, the management thought they had the economical solution.

But these engines of the throttling slide-valve type used 55 lb. of steam per horsepower-hour and generated only 126 hp. on the process steam flow. The balance, 8,000 lb. of steam, expanded from 140 lb. to 50 lb., was not utilized for power generation. The main engine with a steam rate of 19.5 lb. per horsepower-hour was performing inefficiently, but had motors been used for paper-machine drive and this engine operated at 10-lb. back pressure, it could generate a horsepower on half the steam used by the small engines. A further gain could be made by using one of the small engines to expand steam from 140 to 50 lb. for the high-pressure process using 8,000 lb. per hour, thereby securing an additional 100 hp. of byproduct power. This increase in byproduct power from 126 hp. to 352 hp. could be made with the equipment that is considered obsolete by the plant management.

A few years ago I applied for the position of engineer in charge of what was considered a model plant by both the owners and all the local operating engineers. The power unit was a 1,000-kw. Curtis turbine, designed for steam extraction at 2 lb. gage. Heating in winter was done with bled steam, but in summer no steam was bled as there was enough auxiliary exhaust to heat the feed to 210 deg. One process required steam at 30 lb. pressure, while most of the process steam was used at boiler pressure. I suggested turning the auxiliary exhaust into the 30-lb. main and heating the feed with bled steam. After admitting that the auxiliaries would function at 30-lb. back pressure, the superintendent of power condescendingly informed me that this would result in a loss, because more steam would pass through the auxiliaries and the turbine would take more steam. He failed completely to realize that under this plan the auxiliary steam could be charged to the manufacturing department instead of against the power plant, the quantity being, roughly, 5,000 lb. per hour.

When an engineer has been for several years in charge of one plant, jealousy on his part often causes good suggestions from outside engineers to be disregarded or their execution delayed for a long time. In defense of the average engineer in charge it can be said that on more than one occasion he has gone into a run-down plant and effected remarkable economies with old equipment, but owing to lack of appreciation of his efforts in terms of salary or prestige, he has lost much of his enthusiasm for this work.

A. F. SHEEHAN.
Springfield, Mass.

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Bearings Are Still a Subject of Controversy

REFERRING to the editorial in the July 19 issue entitled "Bearings Are Still a Subject of Controversy," my experience has been that with tapered roller bearings it is much easier to replace damaged bearings than it would be in the case of sleeve bearings. Furthermore, the maintenance and replacement of the anti-friction bearing is much less than the maintenance of the sleeve bearing.

Concerning the matter of spare bearings, I find that it is easier to pick up the anti-friction bearings from stock than it is to get the sleeve bearings from the manufacturer. In fact, the users of anti-friction bearings find it unnecessary to carry a large number of spares on hand.

Anti-friction bearings have been gradually adopted on transmission machinery, motors, centrifugal pumps and other equipment, so that stocks of these are now being carried by supply companies in practically every large city throughout the country.

Wilkes-Barre, Pa. G. L. HEIMBACH.

Where Stands German Industry? —Part II

The Program and the Future

By Edward J. Mehren

Vice-President McGraw-Hill Publishing Company, Inc.

THOUGH not formulated in one place, there is a definite program in hand in Germany, a program that is obvious, one might declare, because it is forced by necessity, but a program, nevertheless, that deserves recognition and study. The crux of the situation is the need for export trade and, secondly, for an export trade balance. For the first Germany must make goods that other countries either cannot or do not make or do not make of equal quality, or for equal quality she must make goods cheaper. Other countries must need some German products so badly that they will take the goods over their own tariff walls; and, in turn, Germany must manufacture other goods so well and cheaply that the goods can leap the barriers. Secondly, imports must be reduced, relatively at least; Germany must produce and manufacture as much as she possibly can at home.

Here are two examples of steps taken to increase export trade; they are not the most important, it is true, but they are characteristic of the energy here being displayed.

German commercial shipping (which enables Germany to sell service and therefore represents an "invisible" export) has been built up to over 3,000,000 tons, compared to the 320,000 tons to which it fell under the Versailles Treaty. It is worth noting that the tonnage in 1913 was about 5,000,000.

Secondly, Germany has taken the world's leadership in commercial airplane building and commercial air service. This accomplishment will help increase export trade, through the sale of planes, a high-cost product, and also of service, the latter in the form of airplane routes. The extent of this development can be realized from these figures: In 1926 all the large cities of Germany and some small ones (50 in all) were connected by daily air service, the number of passengers carried was 56,000, the number of miles flown daily, 25,000. Remember too, that Germany has an area about equal that of Texas, and all plane building was forbidden for a number of years following the war.

Reduction of Imports

In the matter of becoming more nearly self-supporting the chemical industry shows striking examples. Germany is now independent of Chile for saltpeter. In fact, she is exporting nitrogen fertilizer made from the air. A second marvelous chemical development is the liquefaction of coal. This process produces motor spirit, lubricating oil and other products. A large plant which will use lignite is now being built on the economic ground of being able to undersell gasoline made from petroleum. In a few years this process is expected to make Germany independent of petroleum supplies—again a reduction of imports.

Without a doubt German science and engineering will go forward in helping industry in other lines, as they are in chemistry, to produce new and superior products with which to develop foreign markets or reduce importation into Germany.

IN PART I of this article published last week, the general conditions in Germany today were described. What, now, of the future? Mr. Mehren's recent first-hand study of the situation, including interviews with representatives of all classes, affords a background for constructive opinion.—Editor.

Going along side by side with the type of efforts described there is a drive for cost reduction in industry that is intense and inspiring. It constitutes a friendly challenge to the scientific and engineering genius of other lands.

Heading all cost reduction efforts is the solid German front of scientific and industrial research which has been renowned for more than a generation. Suffice it to say that its intensity and breadth have been increased under the economic urge pressing on the country. To be noted especially is the attention being given to what might be called research in pure science—the effort to explore new areas and to conquer new realms in the domain of science.

Rationalization

The great drive for industrial cost reduction comes under the head of rationalization—one of the dominant topics in Germany today. By rationalization the Germans mean all devices for industrial cost reduction. They include even the consolidation of industrial corporations, for such consolidations effect economies in overhead and selling, and lower production cost through plant specialization and the transfer of production from uneconomic to economic factory units.

Consolidations have been going on in large number in Germany. The government has encouraged it by temporarily reducing the taxes, for such consolidation only, on real estate transfers and on issues of stock.

Cartels

In addition to these efforts at cost reduction, with all of which we in America are familiar, and in which (except possibly in research) the Germans acknowledge our leadership, the Germans have a device of their own for reducing cost and stabilizing industry. That device is the cartel, which, in essence, is some type of co-operation, chiefly in selling, price agreement and in allotment of production quotas, among manufacturers who are financially independent. The device is legal in Germany. It extends beyond German boundaries, and there are now a number of international cartels.

In general, all the producers in a given line will not come into the cartel, and the competitors who stay out are claimed to keep the cartel prices reasonable. In some cases, right after the war, the government forced producers in certain industries to form a cartel or join an existing one. The compulsory cartels, though, proved unsatisfactory, and all of them except the coal and potash syndicates have been dissolved. One obvious danger confronting any cartel is that the low-cost producer will withdraw. While, in the cartel, he has the advantage of a price fixed with reference to the costs of the high-cost producers, his quota may be unsatisfactorily low. Unless he can force a higher quota from his fellow members, his interests may be served by withdrawing and, with his lower prices, getting a larger share of the business and loading up his plant. The possibility is further cited by German business men as a protection to the public from possible cartel extortion.

Cartel Competition with America

Asked whether the international cartel was designed chiefly as a means of effective competition with America, German business men just laughed. They maintained that European international cartels will reduce competition instead of increasing it, by eliminating below-cost competition. As a matter of fact, after

the raw steel cartel was formed, the price of billets rose five dollars per ton.

Indeed, the Germans declare that we are the people to be feared as below-cost competitors, dumping on the foreign market. With a huge domestic market and, say, 10 per cent of the production of a commodity going abroad, we can afford to sell that 10 per cent, so they argue, far below cost just to load up our factories. Meanwhile the protection of our tariff barriers enables our manufacturers to get a good price at home.

The cartel, it is pointed out, has one great danger, namely, its encouragement of technical stagnation. If the price protection should prove successful over a long period, there would be a tendency to neglect technical research and development.

Looked at fundamentally, it is my feeling, after hearing the discussions at Geneva and talking to people here, that American industry need not fear the competition of German or international groups merely because they are united in a cartel. There is no wonder-working mechanism in the cartel idea itself. It does not lower production cost; it does not lower selling costs if the selling be modern and aggressive. Therefore, if we are "on our toes" technically, if we constantly lower our production costs, we will be able to compete.

One dominant impression made on the visitor in Germany is the spirit of open-mindedness among industrialists. Anything new interests them. They want to learn and adopt the best practice in every field. This attitude, too, is reflected in plant policy. If a more efficient machine is available and the money can be found, the old one goes out.

Such plans and efforts require the leadership of men of large capacity; and in them Germany is not lacking. One is constantly inspired by the men he meets, manufacturers, merchants, bankers—men of deep knowledge of world conditions and of the technique of commerce and industry, men of vision and courage, men who work unceasingly, it would seem, plan intelligently and think clearly.

Evidently, the Germans are being forced to work as have been no people of modern times. Work, whether mental or physical, develops strength. One may well ask, as a very shrewd German suggested to me, whether the Germans might not be forced to become too strong commercially for the best interests of other industrial nations. Some day the handicaps will be removed; then Germany's competition may be overpowering. At least it will tax the genius of the rest of the world.

So, the answers I would hazard regarding the situation in Germany and her future are these:

Germany has made tremendous progress industrially and against heavy handicaps. She is, however, hampered by conditions that make further progress difficult and slow. She is putting forth great effort, and it is making her industrially strong. Eventually, she will play an important part in the world's commercial affairs. She is adaptable and fits herself perfectly into the conditions and requirements of modern industrialism.

For us in the United States the lesson would seem to be this: Just now the competition of Germany will not have serious concern for the American people at large; but as our need for foreign markets grows and Germany's handicaps are reduced, German competition will be of deep concern to us. Let it not be looked forward to as commercial or industrial warfare. It is but the competition that we as Americans expect among ourselves; to the most intelligent, the most efficient shall go the reward. So, too, in the future competition in foreign trade. Germany will be a worthy rival; the tools of competition will be the research laboratory, studies in waste reduction, researches to discover new methods and new products, and, finally, hard and intelligent work.

Low-Temperature Carbonization*

By Roland P. Soule, Ph.D.
International Combustion Engineering Corporation

LOW-TEMPERATURE carbonization is an art that is over a hundred years old. In 1792 an enterprising Scotch mechanic named William Murdoch filled an iron pipe with coal, closed one end, and led a pipe line from the other to a burner over a table in his house. After building a fire under the iron retort, he found he could light the gas at the burner. Here we have the essentials of every coal gas plant of today.

Between 1795 and 1804 Murdoch built several small plants to light factories and the residences of the wealthy but did not patent his invention. The first patent went to Phillippe Lebon, of Paris. Frederick Albert Winsor, a German promoter, obtained the first English patents for the manufacture of gas in 1804. Three years passed before he was permitted to light Pall Mall, which was the first outdoor illumination of any magnitude on record. In 1812 he was granted a charter for the London and Westminster Gas Light & Coke Co. The first gas company in this country was organized in Baltimore, in 1816, by Rembrandt Peale. Boston came next in 1822, and New York in 1823.

The London plant comprised 96 cast-iron retorts, each holding two bushels of coal which were heated by a coal fire to a temperature of about 1,200 deg. F., and yielded about 7,000 cu.ft. of gas per ton of coal.

About 1850 the gas industry began to replace its cast-iron retorts with clay retorts. Clay could be heated to a higher temperature and produced a larger volume of gas from the same weight of coal. It was soon discovered, that the gas became lower in heating value and leaner in illuminants and the coke became denser and more difficult to burn. To cheapen the manufacture of gas and extend its use still farther, it seemed advisable to increase the carbonizing temperatures. Yet under those conditions the coal gas deteriorated in quality.

The chemists whose combined efforts made possible the fullest utilization of the gas from high-temperature carbonization are Bunsen and Welsbach.

Sir William Perkin must also be numbered among the famous chemist benefactors of the gas industry. He was seeking a synthetic substitute for indigo, which was an expensive product of India, and in his experiments with the aromatic hydrocarbons which had been distilled from gas-works tar, he did not discover indigo, but he did blunder upon mauve, the first of that seemingly endless family of coal tar dyes.

The next development of importance was the invention of the carbureted water-gas process by Prof. T. S. C. Lowe, at Norristown, Pa., in 1872. Lowe's contribution was the enrichment of the blue gas to the desired calorific value and candlepower by the addition of oil gas made by cracking a petroleum distillate with the waste heat of the blow gases.

The final factor that permitted gas plants to operate at high temperatures was the appearance of silica brick. Silica brick has made possible our present retort temperatures above 2,000 deg. F., and the gas maker has increased his yield from the 7,000 cu.ft. of Murdoch's day to as much as 12,000 cu.ft. per ton of coal carbonized. The ammonia yield has almost doubled and now amounts to 20 to 30 lb. as the sulphate. In the most up-to-date byproduct coke-oven plants about ten to twelve gallons of coal tar per ton is recovered.

The operation is accomplished in a multitude of small horizontal retorts, from 10 to 15 ft. long and about 15x10 in. in section. Improvements have been made in refractories, in regeneration of waste heat and in automatic charging and discharging, and new types of retorts have been introduced, but the fundamental essentials of the process have changed but little in the last hundred years. The lighting load, lost to

*Abstract of a paper read before the Milwaukee Section of the American Chemical Society.

electricity, has been far more than replaced by a heating load, chiefly domestic cooking and water heating.

The distillation of coal by city gas works is only one side of the established carbonization industry of today. The other side of the picture is the carbonization of coal primarily to produce metallurgical coke. Carbonization has been reviewed where the primary aim is gas, and now there will be a brief review where the manufacture of coke is considered the prime object.

Gas-works coke, when it was first produced, found scant favor with the ironmaste.. When carbonizing temperatures were low, the coke was too soft and weak to sustain the weight of the charge in the furnace. The gas maker found he could command a better price in the domestic fuel market for his free-burning coke than the blast-furnace men would pay. The ironmaster got it in a way that fulfilled these requirements, to wit, the so-called beehive oven. About ten tons of coal to a charge was put in a fireclay chamber shaped like a beehive. This coal was set on fire, and air was admitted through a bottom door in a quantity sufficient to generate enough heat to carbonize the whole charge. The gas and tar vapors expelled from the coal escaped from a top door and burned as they met the atmosphere.

In 1861 two Belgians, Coppee and Carves, looked upon this spectacle with great disfavor. The retort they devised to accomplish this purpose had the narrow rectangular section which characterizes the byproduct oven of today. The carbonization was accomplished by burning the hot gases distilled from the coal in vertical flues along the retort walls. From 1880 to 1885 several other systems were brought out in Belgium and Germany where the coke-ovens employed the maximum flue temperatures to obtain low-volatile coke, to cut down the carbonizing time, and thus increase the capacity of the expensive retorts.

Although these byproduct plants showed profits once they were established, their introduction met with determined resistance in most quarters.

It is quite interesting to note that the development of the modern coke-oven was quite independent of the gas-works retort. Both types produce coke with the simultaneous recovery of gas, tar and ammonia.

The byproduct coke-oven of today is the lord not only of the metallurgical coke industry, but also of the manufactured gas industry. By shortening the ovens, it is possible now to built a coke-oven plant smaller in size but the equal in thermal efficiency and flexibility to one composed of the standard units.

It has been indicated how the apparatus has been evolved to meet most satisfactorily the present demands for coke and gas.

Products of Low-Temperature Carbonization

Let the writer take an inventory of the products of low-temperature carbonization, which means carbonization with fuel temperatures of about 900 to 1,100 deg. F. As compared with high-temperature carbonization, there is obtained first of all a slightly higher yield of coke. Low-temperature coke, or "semi-coke" as it is often called, is much easier to burn than coke without volatile matter. The gas yield from low-temperature carbonization is less than half, and the calorific value is not quite double that usually obtained. The added gas yield is due chiefly to the hydrogen and nitrogen evolved when the final 10 to 15 per cent of the volatile in the coal is distilled off, and also to the decomposition of the tar vapors first formed. The coal in every coke-oven passes through a stage of low-temperature carbonization. The heating is not instantaneous, and there must be a measurable period when the fuel is at a temperature of about 1,000 deg. F. Under these conditions, the maximum yield of tar vapor is obtained, which for most high-volatile bituminous coals amounts to 25 to 35 gal. per ton of coal distilled. This condition is impossible in a coke-oven with its walls at 2,000 deg. F. or higher, and the primary tar vapor enjoys only a transitory existence.

Low-temperature tar is non-aromatic and largely non-paraffinoid. It is not more volatile than coke-oven tar, and the boiling-point curves of the two tars are similar. An outstanding characteristic of low-temperature tar is its high content of phenols. This yield is about ten times that by high-temperature carbonization.

The remaining carbonization product, ammonia, fares badly at low temperature. Less than half the usual quantity is evolved from the coal. To summarize, when carbonizing at about 1,000 deg. F., we obtain less ammonia, less gas but of a higher calorific value, more coke and of better burning properties, and finally, more tar, chiefly phenols mixed with petroleum-like hydrocarbons.

It is the higher yield and special properties of these last two products that have excited the renewed interest in low-temperature carbonization. This interest has probably reached its greatest height in England. The principal British objective in low-temperature carbonization may be summarized as the production of semi-coke for a smokeless domestic fuel, and the recovery of the large yield of tar for uses such as navy bunker oil.

The Germans attach to low-temperature carbonization a slightly different scale of values. They are anxious to make themselves independent of foreign petroleum and to produce liquid fuels from coal.

The great stumbling block in Germany has been the coke. They have no such demand for domestic fuel as exists in England. Their cry is for Diesel oil and petrol. What is to be done with the coke, they ask very justly, if coal is carbonized in the tremendous quantities that will be necessary to produce oil in the needed volume? Dr. Fisher's answer is the transformation of this coke residue into blue gas and the conversion of this blue gas into petrol, or gasoline. Methanol—or methyl or wood alcohol—has already been made in this way.

One of the most striking developments bearing on low-temperature carbonization in German fuel is the Bergius process for the hydrogenation of coal which dates from 1913. Bergius achieved commercialization, and it is understood that an army of 20,000 men is now building a plant of huge proportions at the Leunewerke of the Badische Company. Here we have the direct conversion of coal into oil without recourse to carbonization.

What is the present field for low-temperature carbonization in the United States?

The objective sought is that of making artificial anthracite from bituminous coal. We have a large consuming public in this country accustomed to burn anthracite. Our reserves of bituminous coal are boundless, while those of anthracite are limited. Bituminous coal is cheap, anthracite is expensive. The effort has been made to capitalize the superior qualities of low-temperature coke made from bituminous coal as an anthracite substitute, and to help defray the carbonization expense by the sales of the byproduct gas and tar.

The second American objective in low-temperature carbonization is that of cheapening power-plant fuel. If the revenue from the byproduct is sufficiently greater than the cost of carbonization, then the coke will be cheaper to burn than the coal itself from which it was derived.

Lakeside Carbonization Plant

Combustion efficiencies have already approached their theoretical limit. While there is scant room for increased thermal efficiency, there is a prospect for increased dollar efficiency in carbonization prior to combustion. It was with this object in view that a 200-ton per day carbonization plant, operating on the McEwen-Runge process was erected in the Lakeside power plant of the Milwaukee Railway & Light Company.

It may be asked, What are the credits latent in the byproducts of low-temperature carbonization worthy of all this effort to recover them? It has been mentioned that the ammonia yield is low, less than half that obtained from ordinary byproduct ovens. Within the last five years synthetic ammonia has cut the market price in two. It now scarcely pays to recover and concentrate the very dilute and impure product of coal distillation.

The value of low-temperature tar is a thesis in itself. Opinion at present seems to be divided between assigning it only a fuel-oil value, or the selling price of the many valuable products which may be derived from it.

Many are familiar with the sketch of the coal-tar "tree," with its myriad of branches representing compounds sprouting from every important intermediate. Probably not so many realize that these products, comprising over 99 per cent of the total number derived from coal tar, account for less than

1 per cent of the tar distiller's sales. His chief product in volume is pitch. The pitch in coke-oven tar is 65 to 70 per cent of the total volume. While the market for these oils is increasing, those for the pitch are dwindling. Low-temperature tar contains less pitch and more oil than coke-oven tar. Its 50 to 55 per cent yield of oils is an advantage that can be appreciated when it is realized that they are worth three to four times as much as the pitch.

The tar-distiller's most valuable product, in terms of dollars returned, is creosote oil, the widely used wood-preservative. The chemical preservation of wood is now being extended to a wide variety of material. The sales of creosote have increased to the total of 175,000,000 gal. a year, and it is found necessary to import more than half of this quantity. There can be obtained from low-temperature coal tar more than half of its total volume in the form of creosote oil.

Beginning with the first modern low-temperature carbonization plant of Parker, who in 1906 sought to produce and market semi-coke in England under the name of "Coalite," many attempts have been made to carbonize a stationary charge of coal in an externally heated retort. However, there is today no commercially successful low-temperature plant based on this principle. Every low-temperature process of commercial importance today, treating coal in bulk, finds means of agitating the coal during carbonization and thus exposing fresh surfaces to the hot walls.

Processes such as these are on the borderland of commercial success. Capacity has been increased to a point where investment costs are within reason. They may be able to produce smokeless domestic fuel at a profit, but their conversion costs are much out of line for the pretreatment of power-plant coal. The carbonizing units are still too small, and the necessity of operating moving parts exposed to high temperatures results in high maintenance and depreciation charges.

The goal of minimum fixed charges can be attained only in units of large size. This conception has led to the idea of internal heating. Suppose a tower is built and filled with coal and hot gases are introduced at the bottom to percolate up through the coal to heat each piece to the desired temperature without the difficulty of conduction through thick retort walls. Then cannot the coke be withdrawn continuously from the bottom of the retort as the coal is fed in at the top, sufficient time being given for carbonization? Nature has found a way to balk man in this attempt to circumvent her, however, and the process has not proved to be commercially feasible for the carbonization of coking bituminous coals.

Coking coal, at a temperature somewhere between 600 and 750 deg. F. assumes a plastic, molasses-like consistency which affords an effectual barrier to the passage of heating gases. Once these heating gases are stopped, the molten fuel tends to cool, then freeze in the form of a solid piece that in a large retort may weigh as much as 100 tons.

At Lakeside there is essentially the same plant, except that there is fed into the tower not bulk but pulverized coal, and hence there are preserved all the advantages of carbonizing in bulk. Lakeside has a high capacity with a very low investment. Operation is continuous and labor charges are low, for nothing is handled that cannot be pumped. The advantages of using pulverized coal are manifold. In this form over 100,000,000 times the surface is exposed, as compared with the same weight in solid form. Heat transfer thus becomes exceedingly rapid, and the time of carbonization is reduced from the coke oven's twelve hours to less than a minute. Thus in a retort which will carbonize 200 tons a day, there is under treatment at any one time less than 200 lb. And finally, there is no opportunity for this shower of finely divided particles to knit together in a plastic state.

From a consideration of these principles it is simple to visualize how it is proposed to reduce the cost of carbonization to a point where the revenue from the gas and tar will more than defray the conversion costs. Once such a process is applied to the tonnages of coal consumed by our central stations, it is obvious that the municipal gas situation may be altered. This paper will now be closed by indicating into what channels this gas may pass.

Reference is particularly made to the heating and refrigeration of homes. The application of low-temperature carbonization to the production of a solid smokeless fuel has been discussed. Today there is a strong trend toward oil heating, with its automatic operation and freedom from drudgery. There is ample reason to believe, however, that this is a transition stage and that the ultimate fuel for house-heating is gas. It is cleaner and much quieter to burn. The equipment is cheaper. There is no storage on the premises, with its attendant fire hazard, and there is but scant possibility of an interruption of supply.

Gas men looking into the future are of two schools of thought regarding the house-heating load. One wants to achieve it, and the other is afraid it will be thrust upon him. The reason for hesitancy lies partly in the unbalanced load, heavy in winter, light in summer. How is he to dispose of the tremendous production of coke that will accompany his increased gas manufacture?

The remedy is threefold. First, a source of gas independent of the coke-marketing problem; secondly, a type of gas plant with investment small enough to survive the valleys in the load; and finally, the development of a summer load. It appears entirely possible that in the low-temperature carbonization of pulverized coal prior to combustion in large power plants, all three answers have been found. The coke is disposed of under the boilers. Capital costs are at a minimum. The gas should eventually be cheap enough to develop new markets.

The summer market is refrigeration. Gas refrigerators can be made without moving parts, silent to run, and cheaper than electric in both first and operating costs. The application of gas refrigeration, however, is not to ice boxes alone. Special reference is made to the conditioning of the air in our homes.

"We laugh at the people of six hundred years ago because they thought that coal was not fit to burn. But will not the people of six hundred years hence laugh at us because we thought the coal was fit for nothing but to burn?"

Method for Testing Condenser Leakage*

The testing of condensate to indicate the amount of condenser leakage is quite commonly done by comparing the electrical resistance of a sample of water drawn from the hotwell with the resistance of a sample of condensed steam taken from the body of the condenser. The comparison is usually made by measuring the voltage drop across a fixed electrode separation in the first sample and adding measured quantities of condensing water to the second sample until the same voltage drop is obtained across an equal separation. The amount of condensing water added to the second sample is a measure of the comparative purity of the first, the quantity added being directly proportional to the condenser leakage.

In the plant of the Commonwealth Edison Company at Chicago, there were indications that the sample commonly taken by collecting condensate on a shallow pan located in the body of the condenser, was not representative pure condensate. In order to be sure of its purity, it was decided to secure the sample ahead of the condenser as near the last turbine stage as was practicable.

The condensing apparatus designed to accomplish this consisted of a copper cylinder containing a coil of tubing in which condensing water is circulated. The cylinder, closed at both ends, is bored over about two-thirds of its surface area, with rather larger holes. It is installed inside the exhaust connections in a horizontal position with the unbored portion of its surface at the bottom. The exhaust steam is entrapped through the holes, condensed on the coil and collected in the bottom of the cylinder from where it is drawn off to the outside. The reason for the design of this condenser departing from the simple arrangement of a coil supported over a pan, lies, of course, in the velocity of the steam at the point where condensation is accomplished. Without the protection of the uper part of the cylindrical shell the water condensing on the cooling coil would be blown away as fast as the drops formed.

*Abstract from article by A. E. Grunert, Efficiency Engineer, Commonwealth Edison Co., Published in *Electrical World*.

NEWS *of the* FIELD

Northern States Power Builds Plant at Chippewa Falls

The Northern States Power Co. has started construction on its $3,500,000 power plant at Chippewa Falls, Wis. The new plant, with a capacity of 27,000 hp., will be located on the Chippewa River, about two miles downstream from its present development, which has a capacity of 42,000 hp.

The arrangement of dams and generators, two miles apart, will permit "putting the water to work twice in a half hour," according to the plan outlined by Charles F. Stuart, assistant to the general manager.

The new hydro-electric project marks the progress of the power company in developing a system for the elastic interchange of power between the corporation's generating plants, both steam and hydro-electric in various parts of Wisconsin and Minnesota. The surplus power from the Chippewa Falls plant will be available for use in the Twin Cities and in times of low water the power developed in the steam plants in Minneapolis and St. Paul can be transmitted to districts which are unable to supply the demanded current.

The building of coffer dams to divert the current to one side of the river is the first undertaking on the program in order to permit excavation for the construction of the dam.

Accepts Saluda River Draft—Other Projects Gain

The Lexington Water Power Co. has accepted the draft of the license covering its project on the Saluda River. The license itself was executed and delivered Aug. 1, at which time it was understood the company will let construction contracts with the idea of starting the work on its dam at an early date.

The Federal Power Commission's technical staff is now analyzing the designs for the City of Seattle's Diablo Canyon arch dam. The dam is to be 385 ft. high. Four designs have been submitted. Careful consideration is being given the questions of safety and economy involved.

The studies of the project have progressed far enough to leave little doubt that the site is well adapted to a dam of that type, but final approval has not been given any one of the plans submitted. A protest against the impounding of such a large amount of water has been filed on behalf of the people below the dam who would be endangered in case of its failure.

Engineers familiar with the development of the Potomac, as planned by the Potomac River Corp., take issue with the arguments advanced by the National Capital Park and Planning Commission that the dam at Chain Bridge would endanger a portion of the city of Washington; that it would tend to industrialize the city, and that it would mar the beauty of the gorge of the Potomac. They point out that the type of structure planned at Chain Bridge follows long established practice and contains no unusual features and would be entirely safe.

A.S.M.E. Seattle Meeting Papers of Interest

Among mechanical engineering studies of interest to the Pacific Northwest in the power field, to be included in the program of papers for the Seattle meeting of the American Society of Mechanical Engineers, which will be held Aug. 29-31, are two of especial note.

"Special Diesel Engine Applications," by H. D. Estep, engineer, and Gerald Frink, president, Washington Iron Works, will deal with Diesel drives for logging-machinery, tow boats and ferries.

"Beet Sugar Manufacture," by Wilford V. Cannon, district manager, Utah-Idaho Sugar Co., will treat engineering features specific to beet sugar production.

"The Pulp and Paper Industry of the Pacific Northwest," by C. C. Hockley, consulting engineer, Portland, discusses the development and economic analysis of the pulp and paper industry with description of equipment and processes used. Following this study will be "Investigation of Wood Pulp Industry," by C. Konzo and B. W. Ross, members of the student branch, University of Washington.

De La Vergne Machine Co. Warns of "Representatives"

A man of advanced age traveling under the name of Wolf, accompanied by four mechanics, has recently been posing as a representative of the De LaVergne Machine Co., according to information from the Kansas City office of that organization, made public as a warning to all those who might be approached by this impostor.

According to the report of "Wolf's" activities, he has been busy borrowing small amounts of money wherever he can, stating that he is 76 years of age and has a large family now scattered.

Museum of Engineering Drive Seeks Funds

Progress toward the establishment of the long-planned national museum of engineering and industry is outlined in *The Repertory*, the first number of a proposed official organ of the projected museum. Proofs of the publication given out yesterday list George W. Goethals, Colonel Charles A. Lindbergh, Herbert Hoover, Charles M. Schwab and Melville E. Stone as honorary members.

The plan to erect such a museum in Washington, says *The Repertory*, is backed by the American Society of Civil Engineers, the American Institute of Mining and Metallurgical Engineers, the American Society of Mechanical Engineers and the American Institute of Electrical Engineers. The museum will be a part of the Smithsonian Institution and may be erected in the Mall in Washington.

"We are now prepared to carry out the recommendation of the Committee on Procedure of the four national engineering societies to increase our membership," *The Repertory* continues. "To do this we shall need funds to give nation-wide publicity to the movement."

Syracuse Lighting Co. Buys Control of Seneca Power

Announcement has been made that the Syracuse Lighting Co. has acquired control of the Seneca River Power Co., a large public utility that supplies power and light to a majority of towns and villages in Oswego County.

The Seneca River Co. and the Mexico Electric Co. which it took over last January has been under the control of the Mohawk Hudson Power Co. The Syracuse Corp. has supplied electricity and gas to Syracuse, Eastwood and Solvay and electricity to several surrounding towns and villages.

Akron Installs Plant for Steam Heat and Power

Installation of first units of the new district steam heat and power plant of the Northern Ohio Power & Light Co., Akron, Ohio, is almost completed, company officials announced July 29. Operation will start Oct. 1. The total cost of the project is $1,000,000.

Initial power-house equipment includes two boilers capable of developing a total of 4,500 hp., and a water softening plant which will remove scale-forming minerals.

Power Unit at American Falls for Early Construction

Officials of the United States bureau of reclamation have reached a decision to proceed with the installation of the first unit of the proposed government hydro-electric plant at American Falls.

An appropriation of $700,000, voted for this purpose by the last Congress, became available recently. However, the high stage of water in the Snake River at present prohibits anything in the way of actual construction, and work will not be begun until it has somewhat receded. Definite assurances that the plant will be built this year were contained in a letter written by Federal Commissioner Elwood Mead and addressed to Congressman Addison T. Smith, of Twin Falls.

To Call Bids on Tunnel for Columbia Power Project

Tenders for boring the tunnel in connection with the power development project of the British Columbia Electric Railway Co. at Bridge River will be called for toward the end of August, according to an announcement by officials of the company.

The contract will not only be for work on the tunnel, but will also include building of the surge chamber and intake. The length of the tunnel is estimated at 13,200 ft., with a 13-ft. diameter.

Preliminary work has been in progress at Bridge River for some time, and bunkhouse, workshops and offices are now nearing completion. To provide power for construction purposes, two 610-b.h.p. Diesel engines were purchased in England to generate power. The first of these engines arrived in Vancouver early in July, and was transhipped to Bridge River, while the other one is now due to arrive.

Project on Tennessee Will Embrace Clinch Sites

The East Tennessee Development Co. will not amend its application for power rights on the Tennessee River so as to exclude the sites on the Clinch River which are under suspension because of the effect the operation of a dam at Cove Creek would have on Muscle Shoals. Further study of the project makes it even more certain that the plan of development proposed cannot be split up without destroying the value of its two parts.

In order to develop the maximum resources of the river and to provide the best navigation scheme it is apparent that the Cove Creek reservoir must supply seasonal storage for the entire series of power plants along the Tennessee River. This would mean that the power plant at the dam would be closed for eight or nine months of the year. This method of operation could not be followed by a lessee independent of the operators of the sites on the main river. On the other hand, if operated so as to produce the maximum amount of power at the Cove Creek plant the storage would be of little value to the Tennessee River projects, as a large part of the water would be turned into the Tennessee at a time when the other tributaries would be supplying ample water.

An effort is being made to attach a provision to the Mississippi flood control legislation which would authorize the federal government to build the Cove Creek dam. It is pointed out, however, that the reservoir could not be held empty on the chance that there might be abnormal rains if it is to be used also for power purposes. As a consequence it would have a negligible effect on flood heights in the Mississippi.

Muscle Shoals Town Gives Hard Nut To Crack

Public ownership advocates and those with interests in the vicinity of the Wilson dam gave the War Department a difficult problem when they asked that power be sold to the municipality of Muscle Shoals. Not only is the question one of fundamental policy, but it involves all sorts of physical perplexities.

To figure the cost of a few hundred kilowatt hours at a big plant is a difficult task. It involves the calculation of cost when one of the large generators is operated at 5 per cent of capacity. As no transforming facilities are available at the dam it would be necessary to put it through the transformers at the nitrate plants. There then would be the difficulty of solving what proportion of the costs, including transmission losses, are to be charged to the Alabama Power Co. and to the municipality.

Various complications are introduced by the fact that the dam is under the direction of the Engineer Department, while the nitrate plants are in charge of the Ordnance Department.

The Judge Advocate General has sent all papers back to the engineers for more details and they have been forwarded in turn to the district engineer at Florence. Apparently considerable time must elapse before a final answer can be given the applicants.

New Zealand Increases Need for More Electricity

The demand for electric light and power in New Zealand has arisen 43 per cent in the 11 years of government operation, according to the chief electrical engineer for the New Zealand government, say advices from Consul-General W. L. Lowrie, Wellington, New Zealand, made public by the Department of Commerce.

This increased use of electricity has been more rapid than anticipated, and the power plants are unable to cope with peak loads without the assistance of the different municipal stand-by plants.

The next big work to be undertaken is in the southern part of the South Island, which at present lacks a large government power plant. The potentiality of the source chosen is approximately 1,000,000 hp., but only 100,000 will be developed at first.

Project Sought in Washington

The Cascade Power Co., Seattle, has applied to the Federal Power Commission for a preliminary permit covering a project on May Creek and Lake Isabel, four miles east of Gold Bar, Wash. The water of Lake Isabel will be raised 20 ft. and carried 9,000 ft. to the power house. It is estimated that 5,000 hp. of primary power will be made available, but 10,000 hp. will be installed.

Obituary

H. O. SEYMOUR, director of the Chain Belt Co., Milwaukee, died of heart failure July 23 at his country home, Lake Geneva, Wis. Mr. Seymour was director of the Chain Belt Co. since 1918. He was also president of the First Wisconsin Trust Co., executive vice-president of the First Wisconsin National Bank, and vice-president of the First Wisconsin Co., all of Milwaukee.

Personal Mention

JOHN D. BALL was recently elected chairman of the Milwaukee Section of the American Institute of Electrical Engineers.

C. A. BUTLER, JR., formerly at the Davenport, Iowa, office of the United Light & Power Engineering & Construction Co., is now located at the newly opened Kansas City branch, 519 Railway Exchange Building.

Personal

ALFRED ABBOUD, formerly engineer and construction superintendent for the John Gallivan Co., engineers and contractors, Boston, Mass., has organized ALFRED ABBOUD & CO., INC., ENGINEERS of Boston, for electrical heating, ventilation, power piping and refrigeration work.

T. D. LYNCH, manager of materials and process engineering department, Westinghouse Electric & Manufacturing Co., sailed from New York Aug. 1 for a two month's business tour of Europe to study methods of manufacturing in Germany and England, especially the Westinghouse distributors, Siemens Schuckert of Germany and Metropolitan Vickers of Great Britain. While on the continent he will attend the meetings of the International Congress for Testing Materials, which convenes at Amsterdam, Holland, Sept. 12 to 17.

Business Notes

THE CLIMAX ENGINEERING CO. has removed its Chicago office to 1608 Harris Trust Bldg., 111 West Monroe Street. F. E. Blanchard is in charge.

THE J. L. LATTURE EQUIPMENT CO., of Portland, representatives in Oregon, Washington and Idaho, of the Climax Engineering Co., Clinton, Iowa, are now located at 312-314 E. Madison St., Portland, Ore.

ROBBINS & ROBBINS, 801 Tchouitoulas St., New Orleans, La., have been appointed sales representatives in the States of Louisiana and Mississippi for the Graver Corp., East Chicago, Ind., to handle Graver's complete line, consisting of water softeners, filters, tanks and steel-plate equipment.

THE YARNALL-WARING CO., Chestnut Hill, Philadelphia, manufacturers of power plant equipment, have established a branch office at 314 Wright Bldg., Tulsa, Okla., in charge of Caleb L. Horne as district manager, who comes from the engineering staff of the Texas Co.

THE ANDREWS-BRADSHAW CO., Pittsburgh, Pa., which has for some time past owned a controlling interest in the Tracy Engineering Co., San Francisco, has recently acquired full ownership of that company's plant. The purchase of the Tracy Engineering Co. now gives the Andrews-Bradshaw Co. title to all Tracyfier patents.

Coming Conventions

American Institute of Electrical Engineers. F. L. Hutchinson, secretary, 33 West 39th St., New York City. Pacific Coast convention at Del Monte, Calif., Sept. 13-16.

American Refractories Institute will hold its fall meeting Thursday, Sept. 15, at the Clifton Hotel, Niagara Falls, Canada.

American Water Works Association. California Section, at San Jose, Oct. 5-8; Paul E. Magerstadt, sec., East Bay Water Co., Oakland; Central States Section will hold annual meeting at Akron, Ohio, Sept. 15-16; E. E. Bankson, sec., Union Bank Building, Pittsburgh. North Carolina Section, at Durham, Nov. 7-9; H. G. Baity, sec., Univ. North Carolina, Chapel Hill; Southwest Waterworks Association will meet at Hot Springs, Ark., Oct. 10; Lewis A. Quigley, sec., superintendent of City Waterworks, Fort Worth, Tex.

American Society of Mechanical Engineers. Calvin W. Rice, secretary, 33 West 39th St., New York City. Seattle, Wash. Section, Aug. 29-31.

Canadian Steel and Power Show and technical sessions will be held at the University of Toronto Arena, Toronto, Ont., Aug. 31, Sept. 1 and 2; Campbell Bradshaw, general chairman of exposition committees, 153 University Ave., Toronto, Ont.

National Association of Practical Refrigerating Engineers. Eighteenth annual convention and educational exhibition in Civic Convention Hall and headquarters Hotel Whitcomb, San Francisco, Calif., Nov. 29 to Dec. 2. H. Fox, 5707 W. Lake St., Chicago, Ill.

National Association of Stationary Engineers—Annual convention at Ambassador Hotel, Los Angeles, Calif., Aug. 22-27, in connection with the Pacific Coast Power and Mechanical Exhibit.

National Fuels Meeting, under the auspices of the Fuels Division of the American Society of Mechanical Engineers, will be held Oct. 10-13 at St. Louis, Mo.

Trade Catalogs

AUTOMATIC SWITCHING EQUIPMENT—General Electric Co.'s bulletin GEA-771 announces a direct-current reclosing feeder with a line of air circuit breakers. The equipment is built in capacities of 800 to 3,000 amperes at 600 volts and designed for automatic railway and industrial service stations. It disconnects on overcurrent, and if desired on rate of current change, automatic reclosing occurs after a definite time interval.

GENERATOR VOLTAGE REGULATORS—Bulletin GEA-709 of the General Electric Co. lists and describes automatic voltage regulators for alternating- and direct-current generators, protective relays, for a-c. equipment and speed regulators. Connection diagrams and descriptions of the operation of several types of apparatus are given, explaining their use on generators and exciters, for line drop compensation and other applications. A variety of regulator auxiliary apparatus is described.

OIL CIRCUIT BREAKERS — Bulletin GEA-703 of the General Electric Co., superseding No. 67495.1, describes a line of heavy-duty oil circuit breakers rated at from 500 to 4,000 amperes and 7,500 to 35,000 volts. They are for indoor use and are available for stationary or movable truck mounting. The operating mechanisms are motor operated with single or double reduction gearing depending on the size. A table of interrupting capacities and a page of suggested arrangements are given.

TURBINE - GENERATOR SETS — The General Electric Co. announces in bulletin GEA-598 a series of turbine-generator sets designed to meet the diversity of requirements found in steam-electric plants. Turbines are of the impulse type and designed to meet a variety of steam supply conditions, including mixed-pressure non-condensing operation and extraction of process steam. An elementary explanation of the principle of operation, diagrams and photographs are included.

AMMONIA COMPRESSORS—The De La Vergne Machine Co., refrigerating department, New York City, has issued bulletin No. 182, describing high- and medium-speed horizontal ammonia compressors for direct or belted connection to oil, gas or steam engines or electric motors. The horizontal type of compressor is explained and the construction of the concentric-ring variety of high-speed valve is shown. Other details of the compressor and several photographs of refrigerating plants complete the bulletin.

WATERWHEEL-DRIVEN GENERATORS—The General Electric Co. has issued bulletin GEA-739, superseding No. 40600C. It contains a large number of photographs of hydro-electric installations employing G.E. waterwheel-driven generators in plants in the United States and foreign countries, and several views of dams and reservoirs are shown.

Fuel Prices

COAL

The following table shows the trend of the spot steam market in various coals, f.o.b. mines; mine run, except Pittsburgh gas slack:

Bituminous Net Tons	Market Quoting	Aug. 3 1927
Pool 1	New York	$2.50@$2.75
Smokeless	Boston	1.63
Clearfield	Boston	1.60@ 1.90
Somerset	Boston	1.70@ 2.00
Kanawha	Columbus	1.25@ 1.50
Hocking	Columbus	1.75@ 1.90
Pittsburgh	Pittsburgh	1.90@ 2.15
Pittsburgh gas slack	Pittsburgh	1.30@ 1.45
Franklin, Ill	Chicago	
Central, Ill	Chicago	
Ind. 4th Vein	Chicago	
West Ky	Louisville	2.25@ 2.50
S. E. Ky	Louisville	1.50@ 1.75
Big Seam	Birmingham	1.50@ 2.15
Anthracite Gross Tons		
Buckwheat No. 1	New York	2.50@ 3.25
Buckwheat No. 1	Philadelphia	2.50@ 3.00
Birdseye	New York	1.40@ 1.65

FUEL OIL

New York—Aug. 4, light oil, tank-car lots; 28@34 deg. Baumé, 5c. per gal.; 36@40 deg., 5½c. per gal. f.o.b. Bayonne, N. J.

St. Louis—July 21, tank-car lots, f.o.b. St. Louis; 24@26 deg., $1.65 per bbl.; 26@28 deg., $1.70 per bbl.; 28@30 deg., $1.75 per bbl.; 30@32 deg., $1.80 per bbl.; 32@36 deg., gas oil, 4.6c. per gal.; 38@40 deg., 5½c. per gal.

Pittsburgh—July 27, f.o.b. local refinery; 30@34 deg., fuel oil, 4¾c. per gal.; 36@40 deg., fuel oil, 5c. per gal.

Philadelphia—Aug. 3, 26@30 deg., $2.05@$2.11 per bbl.; 13@19 deg., $1.68@$1.74 per bbl.

Cincinnati—Aug. 2, tank-car lots, f.o.b. local refinery, 24@26 deg. Baumé, 6½c. per gal.; 26@30 deg., 6⅝c. per gal.; 30@32 deg., 7c. per gal.

Chicago—July 30, tank-car lots, f.o.b. Oklahoma, freight to Chicago, 92c. per bbl.; 24@26 deg., 95c. per bbl.; 26@30 deg., 97½@$1.00; 30@32 deg., $1.10.

Boston—Aug. 1, tank-car lots, f.o.b. 12@14 deg. Baumé, 4.3c. per gal.; 28@32 deg., 5¾c. per gal.

Dallas—July 30, f.o.b. local refinery, 26@30 deg., $1.40 per bbl.

NEW PLANT CONSTRUCTION

Calif., Monrovia—City voted $15,000 bonds for waterworks improvements including sinking of wells, pumping equipment, etc.

Calif., Oakland—Mutual Cramery Co., 425 East 14th St., is receiving bids for the construction of a distributing plant including refrigeration plant, etc. on East 14th St. Estimated cost $350,000. Reed & Corlett, Bank of Savings Bldg., are architects.

Colorado—Southern Colorado Power Co., W. N. Clark, Gen. Mgr., Pueblo, has made application to the Federal Power Commission to construct a hydro-electric generating plant in Royal Gorge on the Arkansas River.

Colo., Denver—The Gates Rubber Co., has work under way on the construction of a steam generating plant. Estimated cost $300,000. Wood & Weber, Tramway Bldg., are engineers.

Colo., Pueblo—P. H. Philbin Interests, Congress Hotel, had plans prepared for the construction of a 17 story hotel including refrigeration system, boilers, elevators, etc. at Fourth and Main Sts. Estimated cost $2,000,000. Michaelsen & Rognstad, 3815 West Congress St., Chicago, Ill., are architects.

Ill., Chicago—Chicago Evening Post, 12 South Market St., awarded contract for the construction of a 19 story office building at Wacker Dr. and Fort St. to McLennan Construction Co., 307 North Michigan Ave. Estimated cost $3,150,000.

Ill., Chicago—De Paul Educational Society, 94 East Randolph St., awarded contract for the construction of a 16 story office building at East Lake St. and Garland Court to McLennan Construction Co., 307 North Michigan Ave. Estimated cost $2,000,000.

Ill., Chicago—Garland Court Building Corp., c/o Rissman & Hirshfield, 228 North La Salle St., Archts., awarded contract for masonry, etc. for a 24 story office building at 63-73 E. South Water St. Estimated cost $2,000,000.

Me., Bar Harbor—Bureau of Yards & Docks, Navy Dept., Washington, D. C., plans the construction of a new engine house at Naval Radio Station, Otter Cliffs, here.

Md., Vienna—Day & Zimmerman, 1600 Walnut St., Philadelphia, Pa., Engrs., will receive bids until Aug. 15 for the construction of a power plant here for Delmarva Power Electric Co., Vienna, Md.

Mass., Lynn—Agoos Leather Co., 146 Pleasant St., awarded contract for the construction of a boiler house at W. T. Dinneen Construction Co., 23 Central Ave. Estimated cost $40,000.

Mich., Detroit—Fox Washington Theatre, W. Schaffer, mgr., 1015 Washington Blvd. Bldg. awarded contract for the construction of a 10 story theatre and office building on Woodward Ave. to Aromberg & Freid Co., 21 East 40th St., New York, N. Y. Steam heating and ventilation systems, boilers, elevators, etc. will be installed.

Mo., Kansas City—St. Louis-San Francisco Ry., St. Louis, awarded contract for the construction of a 400 ton automatic electric coaling station here to Roberts & Schaefer Co., 400 North Michigan Ave., Chicago, Ill.

Mo., St. Louis—Missouri Portland Cement Co., 1010 Pine St., will receive bids about Sept. 1 for the construction of a cement plant including transformer house and sub-station, etc. on Prospect Hill. Estimated cost $2,000,000. F. L. Smidth & Co., 50 Church St., New York, are engineers.

N. J., Asbury Park—Kelly Building Co., plans the construction of a 10 story hotel including steam heating system, boilers, elevators, etc. on Kingsley St. Estimated cost $1,500,000. Architect not selected.

N. J., Atlantic City—Hotel Mayfair c/o M. Ellis, 419 Arch St., Philadelphia, Pa., plans the construction of a 19 story hotel including steam heating system, boilers, elevators, etc. on Boardwalk here. Estimated cost $1,500,000. L. I. Brooks, 65 Madison Ave., New York, N. Y., is architect. T. Golding, 597 5th Ave., New York, N. Y., is engineer.

N. J., Bayonne—Jewish Hospital Association, State Theatre Blvd., Jersey City, plans the construction of a 4 story hospital including steam heating system, etc. at Boulevard and 49th St. Estimated cost $2,000,000. Architect not selected.

N. J., Englewood—M. Quinn Corp., 110 West 40th St., is having plans prepared for the construction of a 5 story apartment including steam heating system, boilers, elevators, etc. at Hillside Ave. and Spring Lane. Estimated cost $1,500,000. C. G. Eichholz Jr., 960 Bergenline Ave., Union City, N. J., is architect.

N. J., Teaneck—(mail W. Englewood)—Holy Name Hospital, awarded contract for the construction of a power house to J. L. Bried, West St., Englewood. Estimated cost $100,000 including equipment.

N. J., Trenton—Highway Commission, Broad St., awarded contract for the construction of an office building at West State St. to Karno-Smith Co., Broad St. Bank Bldg. Estimated cost $800,000.

Steam heating system, boilers, etc. will be installed.

N. Y., Chautauqua—City is having plans prepared for waterworks improvements including filtration plant and pumping station. Estimated cost $40,000. Pearse, Greeley & Hansen, 6 North Michigan Ave., Chicago, Ill., are engineers.

N. D., Lehigh—Lehigh Briquetting Co., will soon receive bids for the construction of a briquetting plant including 600 hp. power plant, 500 g.p.m. pumping plant, sewage disposal plant, etc. Estimated cost $700,000. R. W. Richardson, 301 Zenith Bldg., St. Paul, Minn., is engineer.

O., Cleveland—The Great Western Oil Co., E. W. Brown, Pres., 2846 East 37th St., awarded contract for the construction of a boiler house and steam room, etc. to H. K. Ferguson Co., 4900 Euclid Ave. Estimated cost $75,000.

O., Fostoria—The Ohio Farmers Co-Operative Milk Assn., J. J. Prindle, Pres., 3068 West 106th St., Cleveland, awarded contract for the construction of a factory including refrigeration plant to H. Gage Construction Co., Tiffin. Estimated cost $60,000.

O., Hamilton—City is having preliminary plans prepared for the construction of an electric light plant. Estimated cost $500,000. Froelich & Emery, Toledo, are engineers.

Okla., Gotebo—City is having preliminary plans prepared for waterworks improvements including new well triplex pump and motor, etc. Estimated cost $17,500. Engineer not selected.

Okla., Ponca City—City, awarded contract for the construction of a power plant to Interstate Construction Co., 5703 Rockhill St., Kansas City, Mo. Estimated cost $123,960.

Okla., Wagoner—City plans an election Aug. 9 to vote $57,000 bonds for the construction of a new Diesel engine electric light plant including two 300 hp. Diesel engines and generators, etc. Engineer not selected.

Okla., Wewoka—City plans an election Aug. 9, to vote $125,000 bonds for waterworks improvements including filtration plant, pumps, mains, etc. Long & Co., Colcord Bldg., Oklahoma City, are engineers.

Pa., Philadelphia—The Provident Mutual Life Insurance Co., 401 Chestnut St., awarded contract for the construction of a 71 x 111 ft. power house to Turner Construction Co., 17th and Walnut Sts.

Tex., Balmorhea—Borderland Utilities Co., is having plans prepared for the construction of an electric light plant and transmission line to Madera Springs, about 9 mi. from here, also a 25 to 30 ton ice plant. Estimated cost $30,000 and $35,000 respectively. Private plans.

Tex., Edinburg—Pacific Fruit Express Co., 65 Market St., San Francisco, Calif., awarded contract for the construction of an artificial ice plant here, to Ware Co., 1416 East Missouri St., El Paso, Tex. Estimated cost $78,250.

Tex., Quanah—Northern Texas Utilities Co., Wichita Falls, Tex., has acquired a site and plans the construction of a pumping plant near here. Estimated cost $200,000. Complete equipment will be required.

Tex., Quitaque—West Texas Utilities Co., Abilene, has acquired the water and light plants of the Twin City Ice & Electric Co. at Quitaque and Turkey and plans extensions and improvements. Estimated cost to exceed $25,000. Private plans.

Tex., San Antonio—Dairymen's Association of San Antonio, c/o J. C. Laney, Secy. and Mgr., 104 East Josephine St., plans the construction of a creamery. Estimated cost $200,000. Architect not selected.

Machinery and equipment will be required.

Tex., Texas City—Texas-Gulf Power Co., has acquired the power plant of the Texas City Electric Light & Water Co., and plans extensions and improvements. Estimated cost $70,000. Private plans.

Equipment will be required.

Va., Wakefield—Town, R. F. Bain, Mayor, will receive bids until Aug. 15 for the construction of waterworks and sewage systems including sewage disposal plant and pumping station, etc.

W. Va., South Charleston—Westvaco Chlorine Products Inc., A. M. Pitcher, Gen. Mgr., awarded contract for the construction of a plant including boiler house, etc. to H. K. Ferguson Co., 4900 Euclid Ave., Cleveland, O. Four 3,000 kw. rotary converters and one 2,500 turbo generator, etc. will be installed.

Ont., Toronto—R. W. C. Godson, 14 King St. E., is having plans prepared for the construction of a 15 story hotel including steam heating system, elevators, etc. at Bloor and St. George Sts. Estimated cost $2,000,000. E. V. Stoker, 81 Victoria St., is architect.

Equipment Wanted

Electrical Equipment—Dept. of Public Works, R. W. Wolfe, Comr., 406 City Hall, Chicago, Ill., will receive bids until Aug. 10 for complete electrical equipment for a Double Leaf Trunnion Bascule Bridge over the South Branch of the Chicago River at West Roosevelt Rd.

Ice Plant Equipment—Western Ice Co., Seminole, Okla., is in the market equipment for proposed 20 ton ice plant.

Pump—City of Fort Smith, Ark., will soon receive bids for a turbine driven centrifugal pump for proposed waterworks system. Estimated cost $40,000.

Pump and Motor—City of Faxon, Okla., will be in the market for a triplex pump and motor for proposed waterworks improvements. Estimated cost $15,000.

Pumping Equipment—P. S. Anderson, Secy., Alice, Tex., will be in the market for pumping equipment for proposed waterworks system.

Pumping Equipment—City of Pampa, Tex., will be in the market for pumping equipment for proposed waterworks improvements. Estimated cost $70,000.

Pumping Equipment, etc.—North Tiverton Fire Dist., H. Ibbotson, clk., North Tiverton, R. I., will receive bids until Aug. 15 for pumping equipment, etc. for proposed waterworks system.

Pumps, etc.—J. H. Hill, Mayor and Bd. of Alderman, Goldsboro, N. C., will receive bids until Aug. 25 for two dual driven centrifugal pumps complete with starting and controlling equipment for proposed waterworks improvements.

Pumps, Motors, Etc.—A. S. Soule, Secy., Law Bldg., Los Angeles, Calif., will receive bids until Aug. 10 for two horizontal centrifugal pumps, with motors, also one sludge pressure pump, etc. for sludge sewage treatment plant, County Sanitation Dist. 2.

Pumps and Motors, Etc.—City of San Luis Obispo, Calif., will be in the market for pumps and motors, etc. for Acquisition & Improvement Dist. No. 6. Estimated cost $15,000.

PRICES - MATERIALS - SUPPLIES

Electrical prices on following page are to the power plant by jobbers in the larger buying centers east of the Mississippi. Elsewhere the prices will be modified by increased freight charges and by local conditions.

SINCE LAST MONTH

ALL price changes during the last thirty days, in the materials listed, were downward. This movement involved no severe declines but affected to a slight degree, the following: Lead covered cable, in large lots; boiler patch bolts; flexible cord; rubber-covered copper wire; friction and rubber tape; linseed oil; and highest grade babbitt metal.

POWER-PLANT SUPPLIES

HOSE—Quotations at New York warehouses:

	Fire Protection	50-Ft. Lengths
Underwriters' 2½-in., coupled, single jacket		(net) 68c. per ft.
Common, 2½-in., cotton-rubber lined	80c. per ft. list less	50%

Air—Best grade

¾-in., per ft.	3-ply....$0.34	4 ply....$0.42	

Steam—Discounts from List

First grade.....40% Second grade.....40–5% Third grade.....50%

RUBBER BELTING—List price 6-in., 6 ply, $1.83 per lin.ft. The following discounts from list apply to rubber transmission belting:

Best grade..... 50% Second grade..... 50–10%

LEATHER BELTING—List price, 24c. per lin.ft. per inch of width for single ply at New York warehouses.

Grade	Discount from list
Medium	40–5%
Heavy	30–10%

RAWHIDE LACING
- For cut, best grade, 50%, 2nd grade, 60%.
- For laces in sides, best, 41c. per sq.ft.; 2nd, 37c.
- Semi-tanned: cut, 50%; sides, 41c. per sq.ft.

PACKING—Prices per pound at New York warehouses:

Rubber and duck for low-pressure steam, ¾ in.	$0.95
Asbestos for high-pressure steam, ½ in.	1.75
Duck and rubber for piston packing	.95
Flax, regular	1.15
Flax, waterproofed	1.70
Compressed asbestos sheet	.85
Wire insertion asbestos sheet	1.30
Rubber sheet	.50
Rubber sheet, wire insertion	.80
Rubber sheet, duck insertion	.60
Asbestos packing, twisted or braided and graphited, for valve stems and stuffing boxes	1.40
Asbestos wick, ¼- and 1-lb. balls	.50

PIPE AND BOILER COVERING—Discounts, New York warehouses, are as follows:

85% magnesia high pressure		50%
Asbestos, air cell, for low-pressure heating and return lines	4-ply	70%
	3-ply	72%
	2-ply	74%

PORTLAND CEMENT—New York, $2.35 per bbl. without bags, in carload lots delivered on job. Bag charge of 40c. per bbl.

STRUCTURAL STEEL—New York delivered price, beams and channels, 3 to 15-in.; angles, 3 to 16-in., ¼-in. thick; tees, 3-in. and larger; and plates, ¼-in. thick and heavier; all $3.34 per 100 lb.

COTTON WASTE—The following prices are in cents per pound:

	New York	Cleveland	Chicago
White	10.00@13.50	16.00	15.00@20.00
Colored	9.00@13.00	12.00	12.00@17.00

WIPING CLOTHS—Prices per pound in lots of about 600 lb., for washed, white wipers, as follows:

Chicago	$0.15
New York	.15½
Cleveland (*per thousand*)	36.00

LINSEED OIL—These prices are per gallon:

	New York	Cleveland	Chicago
Raw in barrels (5 bbl. lots)	$0.84	$0.91	$0.83½

WHITE AND RED LEAD—Per 100-lb. keg, base price, f.o.b. New York:

	Dry		In Oil	
	Current	1 Yr. Ago	Current	1 Yr. Ago
Red	$13.75	$15.25	$15.25	$16.75
White	13.75	15.25	13.75	15.25

RIVETS—The following quotations are allowed for fair-sized orders from warehouse:

Tank rivets, $\frac{7}{16}$-in., dia. and smaller, list (Apr. 1, 1927) less 50-10% in full keg lots. EXTRA per 100 lb. for ½-in. dia., 35c.; ⅝-in., 15c.; 1-in., 5c.; lengths, 1-in. and shorter, 25c.; longer than 1-in. up to and including 1½-in., 15c.; longer than 5-in., 25c.; standard countersunk head, 25c.

Structural rivets, per 100 lb.:
New York..... $5.00* Chicago... $3.50 Pittsburgh mill $2.75@$3.00

Cone-head boiler rivets, per 100 lb.:
New York..... $5.00* Chicago... $3.70 Pittsburgh mill $3.10@$3.35

*Full kegs.

REFRACTORIES—Prices in car-load lots, f.o.b. plant:

Chrome brick, eastern shipping points	net ton	$45.00
Chrome cement, 40@50% Cr_2O_3, in bulk	net ton	22@25
Chrome cement, 40@50% Cr_2O_3, in sacks	net ton	26@29
Magnesite brick, 9-in. straights	net ton	65.00
Magnesite brick, 9-in. arches, wedges and keys	net ton	71.50
Magnesite brick, Soaps and spits	per ton	91.00
Silica brick, Mt. Union, Pa.	per M	43.00
Clay brick, 1st quality, 9 in. shapes, Pennsylvania	per M	43@46
Clay brick, 1st quality, 9 in. shapes, Ohio	per M	43@46
Clay brick, 1st quality, 9 in. shapes, Kentucky	per M	43@46
Clay brick, 1st quality, 9 in. shapes, Maryland	per M	43@46
Clay brick, 2nd quality, 9 in. shapes, Pennsylvania	per M	35@38
Clay brick, 2nd quality, 9 in. shapes, Ohio	per M	35@38
Clay brick, 2nd quality, 9 in. shapes, Kentucky	per M	35@38
Clay brick, 2nd quality, 9 in. shapes, Maryland	per M	35@38
Chrome ore crude, 40@50%	net ton	18.00@22.50

BABBITT METAL—Delivered, New York, cents per lb.:

Genuine, highest grade	82.00
Commercial genuine, intermediate grade	61.00
Anti-friction metal, general service	31.50
No. 4 babbitt (f.o.b.)	13.00

COLD DRAWN STEEL—Warehouse prices per 100 lb., base, are as follows:

	New York	Cleveland	Chicago
Shafting and screw stock, round and hexagon	$4.00	$3.90	$3.60
Flats and squares	4.50	4.40	4.10

BOILER FITTINGS—F. o. b. New York or Jersey City, discounts on list:

	Current
Copper ferrules	70%
Boiler flanges	65-5%
Boiler stay bolts	60%
Boiler patch bolts	20%
Boiler fitting-up bolts	45%
Pressed steel boiler lugs	10%

WROUGHT PIPE—The following percentage discounts are to jobbers for carload lots at Pittsburgh mill:

BUTT WELD

Inches	Steel Black	Steel Galv.	Inches	Iron Black	Iron Galv.
1 to 3	62	50½	1 to 1½	30	13

LAP WELD

2	55	43½	2	23	7
2½ to 6	59	47½	2½	26	11
7 and 8	56	43½	3 to 6	28	13
9 and 10	54	41½	7 to 12	26	11
11 and 12	53	40½			

BUTT WELD, EXTRA STRONG, PLAIN ENDS

1 to 1½	60	49½	1 to 1½	30	14
2 and 3	61	50½			

LAP WELD, EXTRA STRONG, PLAIN ENDS

2	53	42½	2	23	9
2½ to 4	57	46½	2½ to 4	29	15
4½ to 6	56	45½	4½ to 6	28	14
7 and 8	52	39½	7 and 8	21	7
9 and 10	45	32½	9 to 12	16	2
11 and 12	44	31½			

BOILER TUBES—Following are net prices per 100 ft. in New York warehouse of tubes manufactured according to specifications of the American Society of Mechanical Engineers.

Size	Lapweld Steel	C. C. Iron	Seamless Steel
1	.....	.....	$17.07
1¼	.....	.....	19.20
1½	.....	$38.00	17.92
1¾	.....	28.50	20.48
2	$17.33	25.00	20.24
2¼	19.84	28.25	23.00
2½	21.60	34.00	26.03
3	25.50	42.50	27.04
3½	30.25	49.50	30.67
3¾	31.50	52.75	33.33
4	38.03	67.00	40.11

Tubes 2½ in. diameter, or smaller, over 18 ft. long, 10 per cent extra.

These prices are net per 100 ft. based on stock lengths. If cut to special lengths, billing will be based on the entire stock lengths.

In addition to the above, standard cutting charges are as follows:

2 in. and smaller,	5c. per cut.	3 in.,	9c. per cut
2½ and 2¾ in.,	6c. per cut.	3½ to 4 in.,	10c. per cut

ELECTRICAL SUPPLIES

ARMORED CABLE—Price per 1,000 ft.—5 per cent. 10 days.

B. & S. Size	Two Cond. M Ft.	Three Cond. M Ft.	Two Cond. Lead M Ft.	Three Cond. Lead M Ft.
No. 14 solid	$30.00 (net)	$46.00 (net)	$180.00	$220.00
No. 12 solid	136.00	180.00	225.00	275.00
No. 10 solid	185.00	235.00	275.00	325.00
No. 8 stranded	305.00	375.00	420.00	500.00
No. 6 stranded	440.00	530.00	615.00	.....

From the above lists discounts are:		Lead Covered
Less than coil lots	50%	20%
Coils to 1,000 ft	60%	30%
1,000 to 5,000 ft	65%	35%
5,000 ft. and over	67%	38%

CONDUIT—Price per 1,000 ft.; **ELBOWS AND COUPLINGS**, Per 100 pieces, f.o.b. New York, with 10-day discount of 5 per cent.

Size In.	Conduit Black Per M	Conduit Galvanized Per M	Elbows Black Per C	Elbows Galvanized Per C	Couplings Black Per C	Couplings Galvanized Per C
¼	$56.50	$61.34	$7.76	$8.83	$4.52	$4.92
½	72.07	78.63	10.21	11.63	6.46	7.03
1	103.31	113.00	15.10	17.21	8.39	9.13
1¼	139.77	152.88	20.51	23.07	11.78	12.75
1½	167.12	182.79	27.34	30.76	14.56	15.75
2	224.85	245.94	50.13	56.40	19.41	21.01
2½	355.50	388.85	82.03	92.28	27.73	30.01
3	464.88	508.50	218.74	246.10	41.59	45.01
3½	585.30	637.74	483.04	543.46	55.46	60.02
4	714.17	776.30	558.23	628.06	69.32	75.02

CONDUIT BODIES AND FITTINGS—Black or galvanized.

	Less than $10 list	$10 list to $100	$100 list and over
Standard package	10%	20%	28%
Less than standard package	5%	10%	20%

CUT-OUTS—Following are net prices each in standard-package quantities:

CUT-OUTS, PLUG, SOLID NEUTRAL OR 2 FUSE

S. P. M. L.	$0.12	D. P. D. B.	$0.31
D. P. M. L.	.16	T. P. S. B.	.35
T. P. M. L.	.27	T. P. D. B.	.47
D. P. S. B.	.16		

CUT-OUTS, N. E. C. FUSE, SOLID NEUTRAL OR 2 FUSE

	0-30 Amp.	31-60 Amp.	60-100 Amp.
D. P. M. L.	$0.27	$0.70	$1.75
T. P. M. L.	.40	1.00	2.30
D. P. S. B.	.35	.87	.....
T. P. S. B.	.67	1.50	.....
D. P. D. B.	.65	1.75	.....
T. P. D. B.	1.12	3.00	.....
T. P. to D. P. D. B.	.75	2.10	.....

FLEXIBLE CORD—Price per 1,000 ft. in coils of 250 ft.:

No. 18 cotton reinforced heavy		$17.75
No. 16 cotton reinforced heavy		22.00
No. 18 cotton reinforced light		14.50
No. 16 cotton reinforced light		18.35
No. 18 cotton Canvasite cord		14.75
No. 16 cotton Canvasite cord		17.20
No. 16 super service cord or similar (2 wire) in 1,000 ft	$72.00	*80.00
No. 14 super service cord or similar (2 wire) in 1,000 ft	110.00	*122.00

*Less than 1,000 ft.

NATIONAL ELECTRIC CODE FUSES, NON-REFILLABLE—

250-Volt	Std. Pkg.	List	600-Volt	Std. Pkg.	List
3-amp. to 30-amp.	100	$0.15	3-amp. to 30-amp.	100	$0.30
35-amp. to 60-amp.	100	.30	35-amp. to 60-amp.	100	.60
61-amp. to 100 amp.	50	.90	65-amp. to 100-amp.	50	1.50
101-amp. to 200-amp.	25	2.00	110-amp. to 200-amp.	25	2.50
201-amp. to 400-amp.	25	3.60	225-amp. to 400-amp.	25	5.50
401-amp. to 600-amp.	10	5.50	450-amp. to 600-amp.	10	8.00

Discount: Less than one-fifth standard package, 60%; one-fifth to standard package, 64%; standard package, 68%.

RENEWABLE FUSES—List price each:

Sizes	250-Volt List-Price	600-Volt List-Price	Std. Pkg. Quantity	Carton Quantity
1 to 30-amp.	$0.50	$1.10	100	10
35 to 60-amp.	1.00	1.25	100	10
65 to 100-amp.	2.00	3.00	50	5
110 to 200-amp.	4.00	5.00	25	5
225 to 400-amp.	7.50	11.00	25	1
450 to 600-amp.	11.00	16.00	10	1

REFILLS—

1 to 30-amp.	$0.03 ea.	$0.05	100	100
35 to 60-amp.	.05 ea.	.06	100	100
65 to 100-amp.	.10 ea.	.10	50	50
110 to 200-amp.	.15 ea.	.15	25	50
225 to 400-amp.	.30 ea.	.30	25	25
450 to 600-amp.	.60 ea.	.60	10	10

Discount **Without** Contract—Fuses:	
Broken carton	5%
Unbroken carton but less than standard pkg.	22%
Std. pkg.	40%
Discount Without Contract—Renewals:	
Less than std. pkg.	Net list
Standard package	40%
Discount With Contract—Fuses:	
Broken cartons	10%
Unbroken cartons but less than standard package	26%
Standard package	42%
Discount With Contract—Renewals	
Less standard package	Net list
Standard package	42%

FUSE PLUGS, MICA CAP—

0-30 ampere, standard package (500)	$2.75
0-30 ampere, less than standard package	3.00

LAMPS—Below are present quotations in less than standard package quantities on Mazda standard A type bulbs:

100—130 Volt Watts	Type	Price Each	200—260 Volt Watts	Type	Price Each
15	A 17	$0.23	Special		
General			25	A 19	$0.28
25	A 19	.23	50	A 21	.28
40	A 21	.23	100	A 23	.50
50	A 21	.25			
60	A 21	.25			
100	A 23	.40			

Standard pkg. quantities are subject to discount of 10% from list. Annual contracts ranging from $75 to $300,000 net, allow a discount of 15 to 40% from list.

PLUGS, ATTACHMENT—

	Each
Porcelain separable attachment plug	$0.18
Composition 2-piece attachment plug	.27
Swivel attachment plug	.12
Small size—2 Pc. Plug—Composition	.07

RUBBER-COVERED COPPER WIRE—Per 1000 ft. f. o. b. New York:

No.	Solid Single Braid	Solid Double Braid	Stranded, Double Braid	Solid Duplex
14	$5.80	$9.00	$10.80	$16.75
12	9.70	12.20	14.20	23.20
10	12.80	15.70	18.10	30.15
8	18.70	21.40	23.70	41.75
6	.....	.....	33.75	.....
4	.....	.....	47.80	.....
2	.....	.....	66.25	.....
1	.....	.....	91.00	.....
0	.....	.....	112.50	.....
00	.....	.....	133.00	.....
000	.....	.....	159.40	.....
0000	.....	.....	190.24	.....

SOCKETS, BRASS SHELL—Price each, net:

	½ In. or Pendant Cap Key	½ In. or Pendant Cap Keyless	½ In. or Pendant Cap Pull	¾ In. Cap Key	¾ In. Cap Keyless	¾ In. Cap Pull
Standard package	$0.17	$0.15	$0.22	$0.20	$0.18	$0.25
Unbroken carton	.18	.16	.23	.22	.19	.26
Broken carton	.20	.18	.25	.24	.21	.28

WIRING SUPPLIES—

Friction tape, ¾ in., less 100 lb., 31c. lb.; 100 lb. lots	29c. lb.
Rubber tape, ¾ in., less 100 lb., 33c. lb.; 100 lb. lots	31c. lb.
Wire solder, less 100 lb., 33c. lb.; 100 lb. lots	31c. lb.
Soldering paste, 2 oz. cans	$1.00 doz.

ENCLOSED SWITCHES, KNIFE—Safety type, externally operated, 250 d.c. or a.c., N.E.C.

TYPE "C" FUSED BOTTOM

Size, Amp.	Double Pole, Each	Three Pole, Each	Four Pole Each
30	$4.50	$6.00	$7.25
60	7.50	8.25	10.50
100	10.50	13.00	22.50
200	16.00	20.00	36.00

Discounts:	
Less than $25.00 list value	30%
$25.00 to $50.00 list value	30–5%
$50.00 list value or over	35%